Operator's Manual

The Coherent Mira Model 900-P Laser

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Sabre: S/N P797 SBR
Head:

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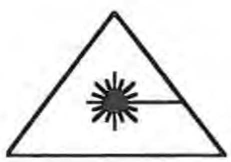
PREFACE

This manual contains user information for the Mira model 900-P modelocked titanium:sapphire laser when pumped with either an 8 or 12 to 14 watt ion laser. Pump lasers recommended include the Coherent Model 200, 300, and 400 ion lasers equipped with PowerTrack™. This manual does not support other pump lasers.

Read this manual carefully before operating the laser for the first time. Special attention should be given to the material in Chapter One, Laser Safety, that describes the safety features built into the Laser.



Use of controls or adjustments or performance of procedures other than those specified in this manual may result in hazardous radiation exposure.

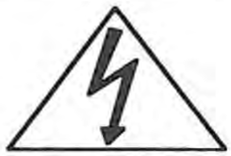
U.S. EXPORT CONTROL LAWS COMPLIANCE

It is the policy of Coherent to comply strictly with U.S. export control laws.

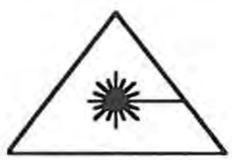
Export and re-export of lasers manufactured by Coherent are subject to U.S. Export Administration Regulations, which are administered by the Commerce Department. In addition, shipments of certain components are regulated by the State Department under the International Traffic in Arms Regulations.

The applicable restrictions vary depending on the specific product involved and its destination. In some cases, U.S. law requires that U.S. Government approval be obtained prior to resale, export or re-export of certain articles. When there is uncertainty about the obligations imposed by U.S. law, clarification should be obtained from Coherent or an appropriate U.S. Government agency.

SYMBOLS USED IN THIS DOCUMENT



This symbol is intended to alert the operator to the presence of dangerous voltage within the product's enclosure that may be of sufficient magnitude to constitute a risk of electric shock and to indicate possible risk of equipment damage.



This symbol is intended to alert the operator to the danger of exposure to hazardous visible and invisible laser radiation.

This symbol is intended to emphasize the presence of important operating and maintenance instructions.

Operator's Manual

Chapter One
Laser Safety

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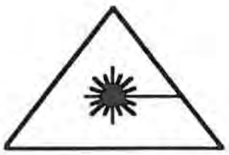
OPTICAL SAFETY

Laser light, because of its special properties, poses safety hazards not associated with light from conventional sources. The safe use of lasers requires that all laser users, and everyone near the laser system, are aware of the dangers involved. The safe use of the laser depends upon the user being familiar with the instrument and the properties of coherent, intense beams of light.



Direct eye contact with the output beam from the laser will cause serious damage and possible blindness.

The greatest concern when using a laser is eye safety. In addition to the main beam, there are often many smaller beams present at various angles near the laser system. These beams are formed by specular reflections of the main beam at polished surfaces such as lenses or beamsplitters. While weaker than the main beam, such beams may still be sufficiently intense to cause eye damage.

Laser beams are powerful enough to burn skin, clothing or paint. They can ignite volatile substances such as alcohol, gasoline, ether and other solvents, and can damage light-sensitive elements in video cameras, photomultipliers and photodiodes. The laser beam can ignite substances in its path, even at some distance. The beam may also cause damage if contacted indirectly from reflective surfaces. For these reasons, and others, the user is advised to follow the precautions below.

1. Observe all safety precautions in the preinstallation and operator's manual.
2. Extreme caution should be exercised when using solvents in the area of the laser.
3. Limit access to the laser to qualified users who are familiar with laser safety practices and who are aware of the dangers involved.
4. Never look directly into the laser light source or at scattered laser light from any reflective surface. Never sight down the beam into the source.
5. Maintain experimental setups at low heights to prevent inadvertent beam-eye encounter at eye level.

Laser safety glasses can present a hazard as well as a benefit; while they protect the eye from potentially damaging exposure, they block light at the laser wavelengths, which prevents the operator from seeing the beam. Therefore, use extreme caution even when using safety glasses.

6. As a precaution against accidental exposure to the output beam or its reflection, those using the system should wear laser safety glasses as required by the wavelength being generated.
7. Avoid direct exposure to the laser light. The intensity of the beam can easily cause flesh burns or ignite clothing.
8. Use the laser in an enclosed room. Laser light will remain collimated over long distances and therefore presents a potential hazard if not confined.
9. Post warning signs in the area of the laser beam to alert those present.
10. Advise all those using the laser of these precautions. It is good practice to operate the laser in a room with controlled and restricted access.

Electrical Safety

The Mira uses AC and DC voltages in the laser head and controller. All units are designed to be operated with protective covers in place. Certain procedures in this manual require removal of the protective covers. These procedures are normally used by a qualified trained service personnel. Safety information contained in the procedures must be strictly observed by anyone using the procedures.

Pump Source

Observe all safety precautions associated with the pump laser. Refer to the pump laser operator's manual for additional safety precautions.

CDRH Compliance

The following safety features incorporated in the laser conform to United States Government requirements 21 CFR Subchapter J as administered by the Center for Devices and Radiological Health (CDRH).

Protective Housing

The laser head is enclosed in a protective housing which prevents human access in excess of the limits of class one radiation as specified in the Federal Register, July 31, 1975, Part II, Section 1040.10 (f) (1) and Table 1-A except for the output beam which is class 4.

Hazardous Radiation Exposure

Use of controls or adjustments or performance of procedures other than those specified in the manual may result in hazardous radiation exposure.

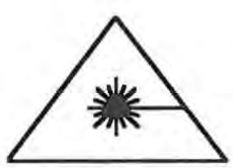
Location of CDRH Compliance Labels

Refer to Figure 1-1 for a description and location of all CDRH required labels. These include warning labels indicating removable or displaceable protective housings, apertures through which laser radiation is emitted and labels of certification and identification (CFR 1040.10(g)), (CFR 1010.2), and (CFR 1010.3).

- When the pumping beam is allowed to impinge on the titanium:sapphire crystal, both laser and collateral radiation are produced. The laser beam is emitted from the laser aperture which is clearly labeled:

AVOID EXPOSURE
VISIBLE AND INVISIBLE LASER RADIATION IS EMITTED FROM THIS APERTURE.

- The laser is designed to be used with the covers in position and this cover shields the operator from all collateral radiation. During initial alignment and maintenance operations, such as mirror alignment, it will be necessary to remove the covers. The covers are not interlocked with the circuitry of the pumping laser but a label provides a warning about exposure to the radiation.



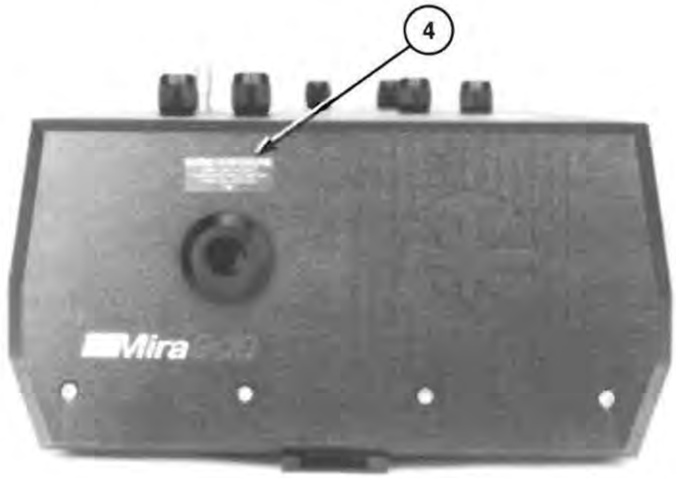
Operation of the laser with the covers removed will allow access to hazardous visible and invisible radiation. The laser housings should only be opened for the purposes of maintenance and service by trained personnel cognizant of the hazards involved.

Extreme caution must be observed in operating the laser with the cover removed. There are high-power reflections which may exit at unpredictable angles from the laser head. These beams have sufficient energy density to cause permanent eye damage or blindness.

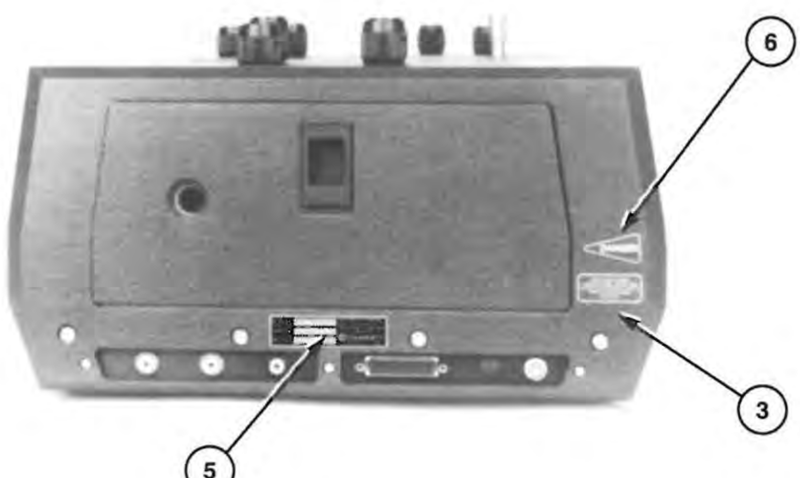
The Center for Devices and Radiological Health regulations apply only within the United States.

CDRH COMPLIANCE

1. Effective August 2, 1976, Coherent lasers are certified to comply with the Federal Regulations (21 CFR Subchapter J) as administered by the Center for Devices and Radiological Health.
2. The Mira laser does not include an integral power source; it utilizes the output beam of an ion laser to produce coherent light.



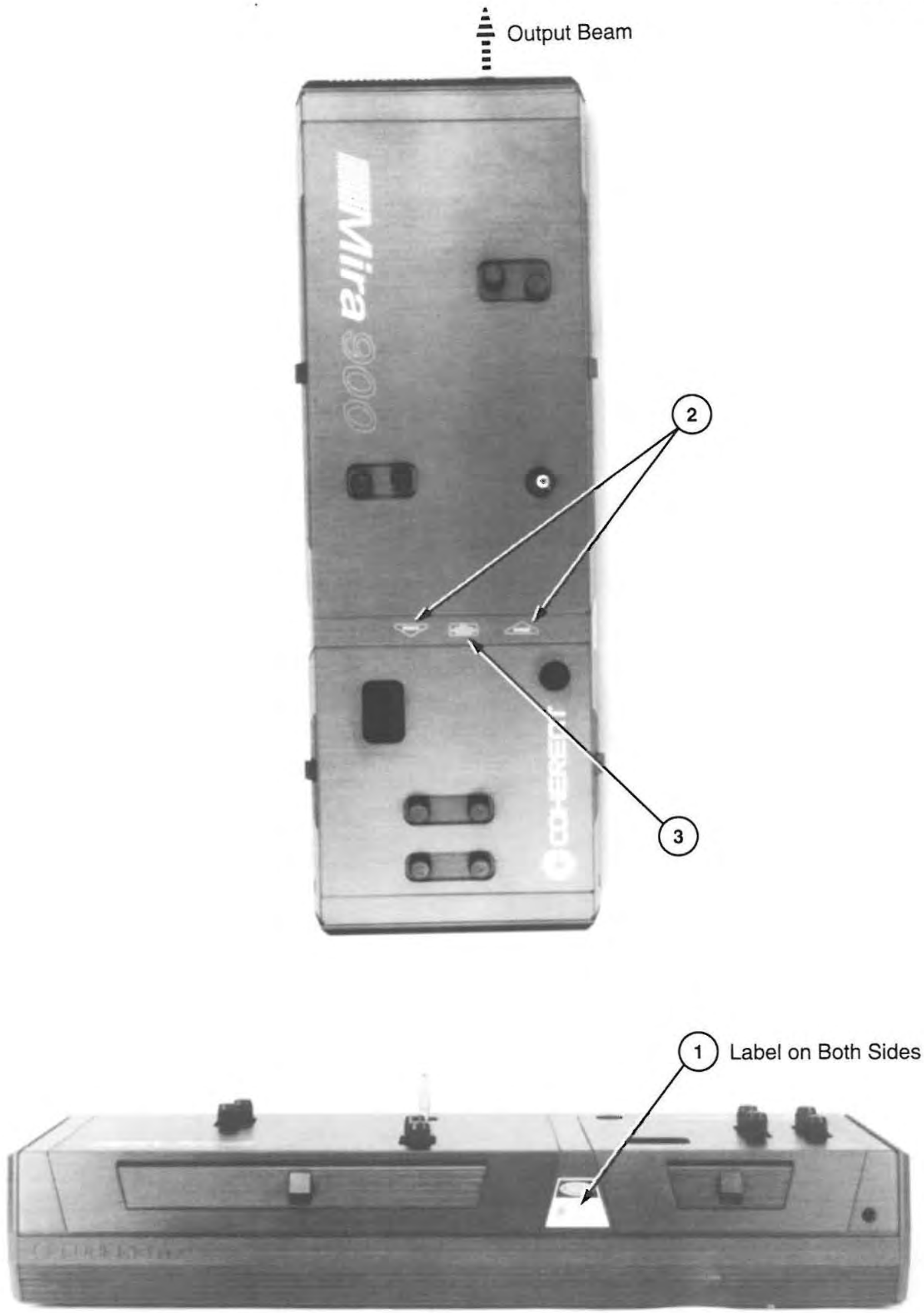
Front Bezel



Rear Bezel

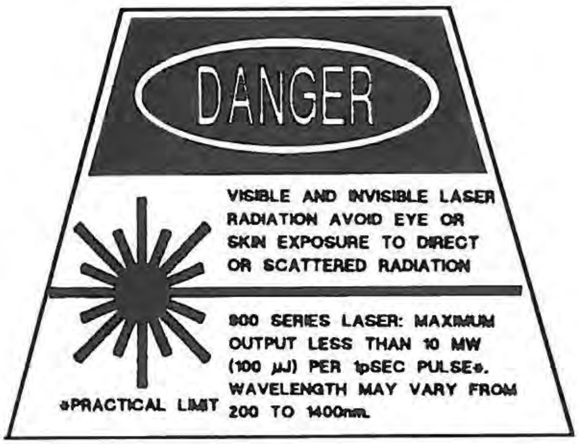
Note: Key is located on sheet 3 of 3

Figure 1-1. Safety Features and Labels (Sheet 1 of 3)



Note: Key is located on sheet 3 of 3

Figure 1-1. Safety Features and Labels (Sheet 2 of 3)



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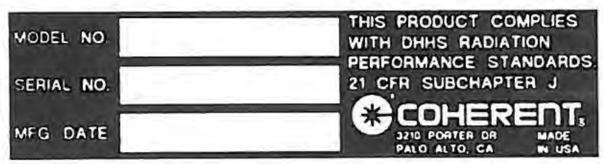

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Figure 1-1. Safety Features and Labels (Sheet 3 of 3)

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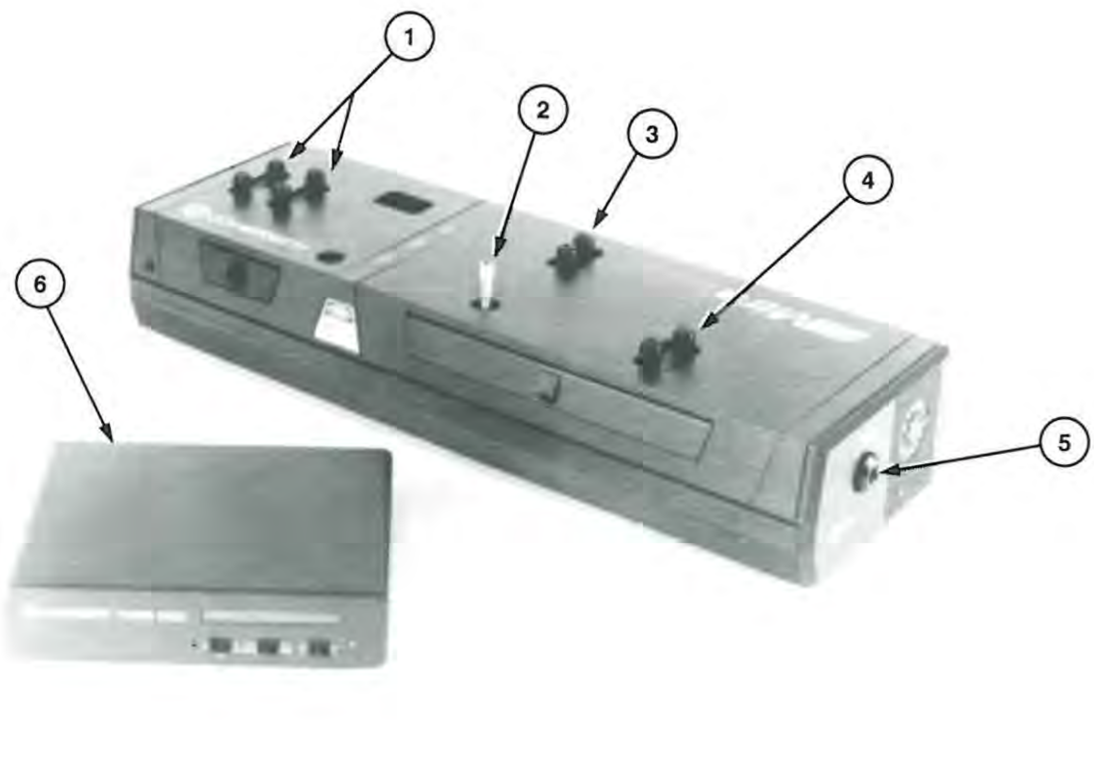
Chapter Two
Description and Specifications

Coherent

SYSTEM DESCRIPTION

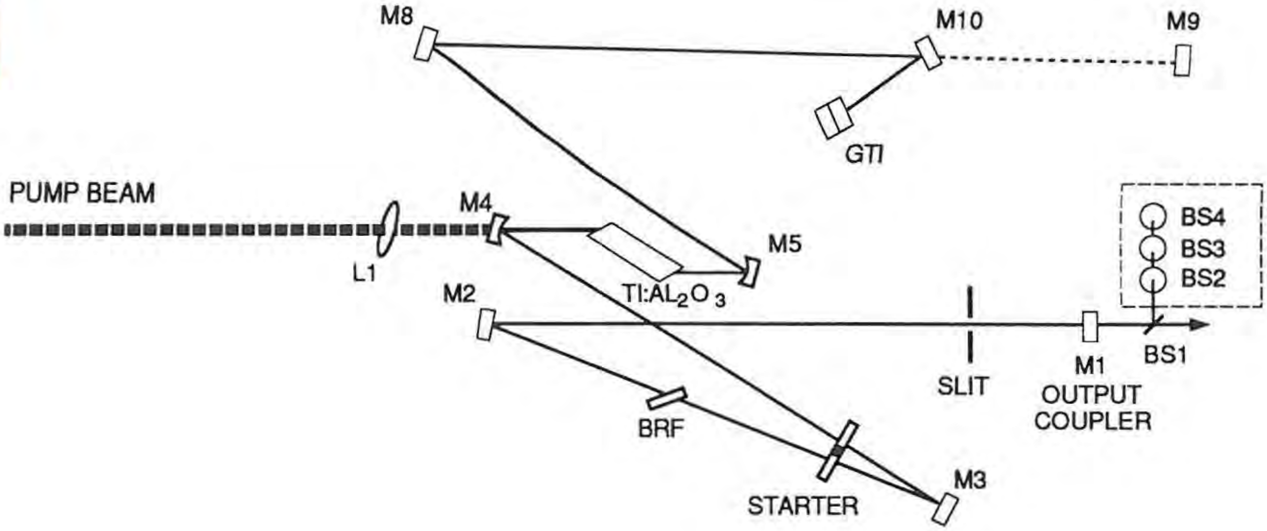
The Model 900-P Mira is a modelocked ultrafast laser that uses titanium:sapphire as the gain medium and is tunable from approximately 700 to 1000 nm. It consists of the laser head and separate controller. The Mira system has two pump power configurations. The low power configuration uses 8 Watt multiline visible from the Innova 200, 310, or 400 ion lasers equipped with PowerTrack™. The high power configuration uses 12 to 14 Watt multiline from the Innova 200 or 400 ion lasers. The Mira laser head is illustrated in Figure 2-1.

The technique used to modelock the Mira laser is referred to as Kerr Lens Modelocking (KLM). The optical cavity is specifically designed to utilize changes in the spatial profile of the beam produced by self-focusing from the optical Kerr effect in the titanium:sapphire crystal. This self-focusing results in higher round trip gain in the modelocked (high peak power) versus CW (low peak power) operation due to an increased overlap between the pumped gain profile and the circulating cavity mode. In addition, an aperture is placed at a position within the cavity to produce lower round trip loss in modelocked versus CW operation (i.e., a location where the modelocked beam diameter is smaller).



1. Pump optics controls
2. Tuning (BRF) controls
3. End mirror (GTI) controls
4. Aperture (slit) controls
5. Output beam aperture
6. Controller

Figure 2-1. Mira Model 900 Laser



BRF : Birefringent filter
BS : Beamsplitter
GTI : Gires-Tournois Interferometer
L : Focusing lens
M : Mirror
$TiAl_2O_3$: Titanium:sapphire crystal

Figure 2-2. Optical Schematic

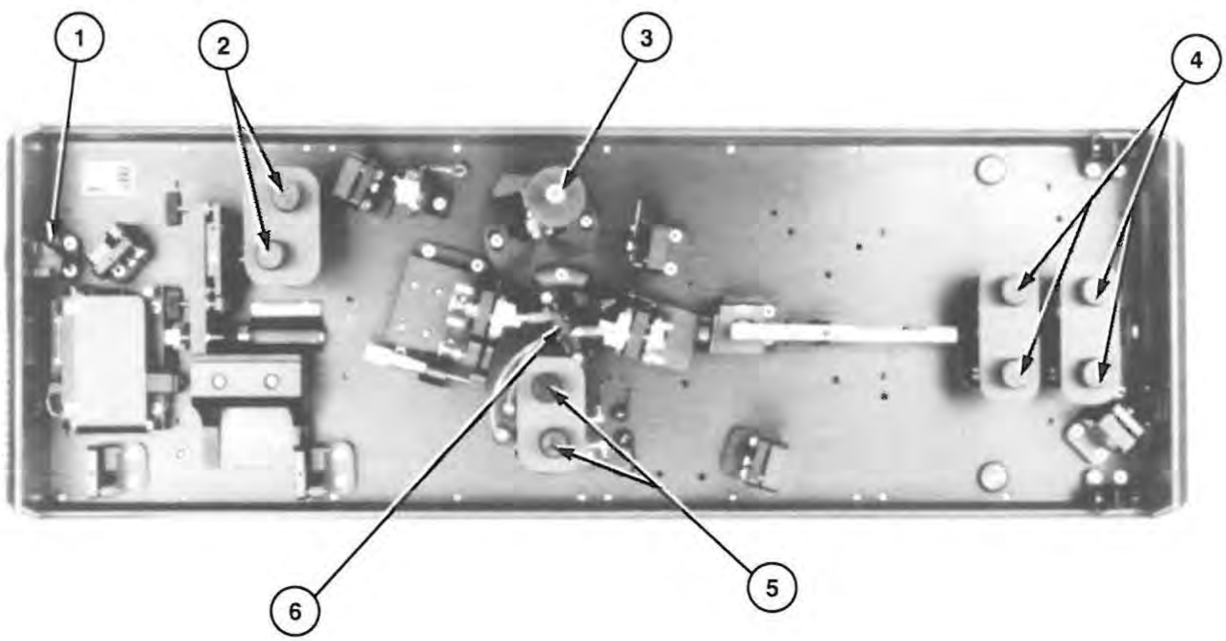
The required intracavity group velocity dispersion compensation for picosecond pulses is generated via a Gires-Tournois Interferometer end mirror in the cavity. The group velocity dispersion provided by the GTI is monitored and adjusted to the correct value by a proprietary servo loop referred to as β-lock. A detailed description of β-lock can be found in the chapter entitled, Theory of Operation.

Features included in the system to aid alignment and optimization include:

- Built in alignment apertures.
- Internal power meter.
- Internal fast photodiode.
- CW component detector (external scanning etalon)
- Modelocking starter (galvo mounted Brewster plates)
- β-lock (GVD) measurement and control system

The controller monitors the photodetectors located inside the laser head. The photodetectors provide fluorescence level, GVD, and power level signals to the controller for alignment and routine monitoring of the output beam. The controller also provides drive voltages to operate the PZT, starter and the etalon galvos. The controller monitors the CW component in the output beam through one of the photodetectors and will automatically turn the starter on to establish modelocked operation.

The access hatches use a latching mechanism in place of screws. This allows easy access to the laser cavity and creates an air tight seal. The controls that are frequently used during daily operation are accessible through the covers. The function of all Mira controls are described in Chapter Three. Major laser head components with all three covers removed are illustrated in Figure 2-3.



1. Output beam aperture
2. Slit controls
3. BRF controls
4. Pump mirror controls
5. GTI alignment controls
6. Titanium:sapphire crystal assembly

Figure 2-3. Major Laser Head Components

Table 2-1. Mira Laser Specifications

SPECIFICATIONS		
Pump laser [1]	Innova 200/300/400	Innova 200/400
Pump power	8 Watts	12 to 14 Watts
TYPICAL TUNING RANGES [2]		
SW optics set	720 to 800 nm	720 to 800 nm
MW optics set	800 to 900 nm	800 to 900 nm
LW optics set	890 to 990 nm	890 to 990 nm
Average power: SW	600 mW	1300 mW
MW	600 mW	1300 mW
LW	270 mW	TBA
Autocorrelation [3]	< 3 ps	< 3 ps
Repetition rate	76 MHz	76 MHz
Noise [4]	<2%	<2%
Beam diameter	0.8 mm ±0.1	0.8 mm ±0.1
Divergence [5]	1.5 mrad ±0.2	1.5 mrad ±0.2
Spatial mode [6]	TEM_{00}	TEM_{00}
Polarization	Horizontal	Horizontal

1. Specifications only apply with the recommended pump lasers at the power levels indicated.
2. System is shipped and installed in only one optics set specified at the time of purchase.
3. Multiply by 0.65 $sech^2$ deconvolution factor for pulse duration.
4. RMS measured in a 10 Hz to 2 MHz bandwidth.
5. Full angle divergence.
6. Typical measured M^2 value of 1.1.

All specifications are subject to change without notice.

Operator's Manual

Chapter Three
Controls and Indicators

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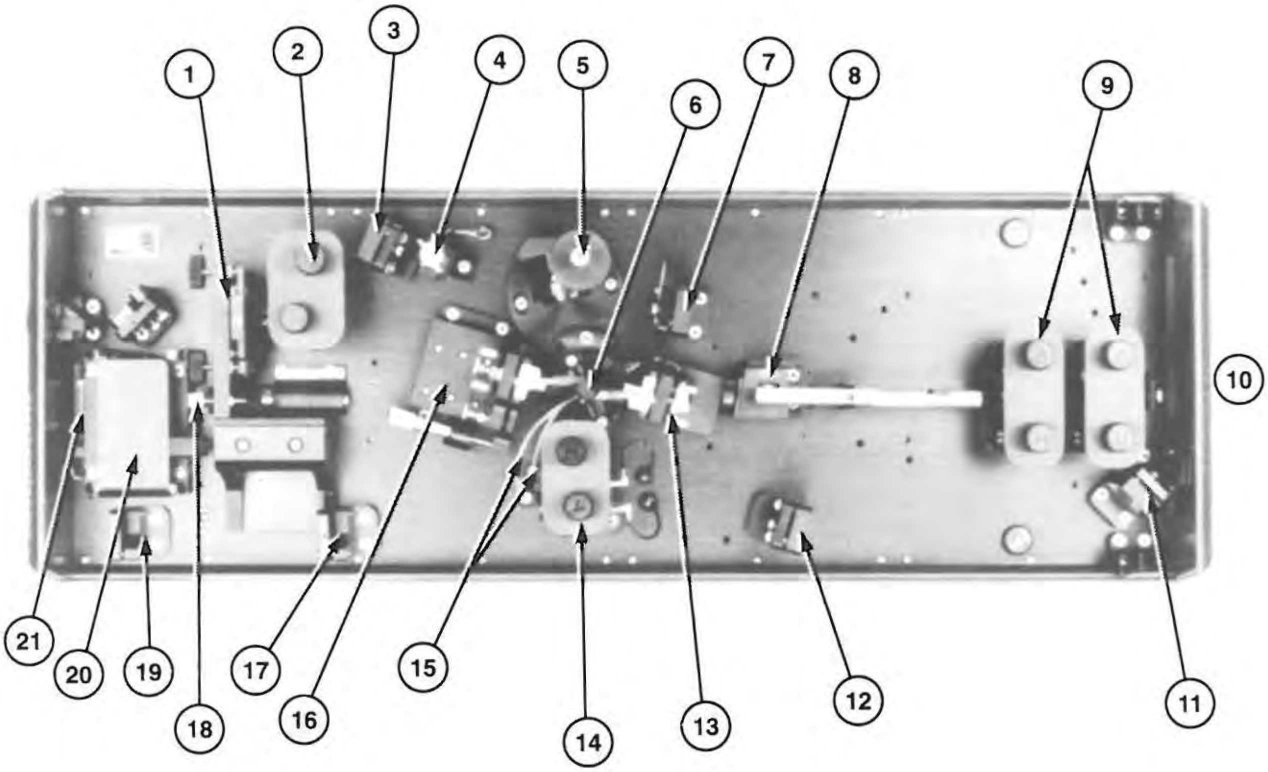
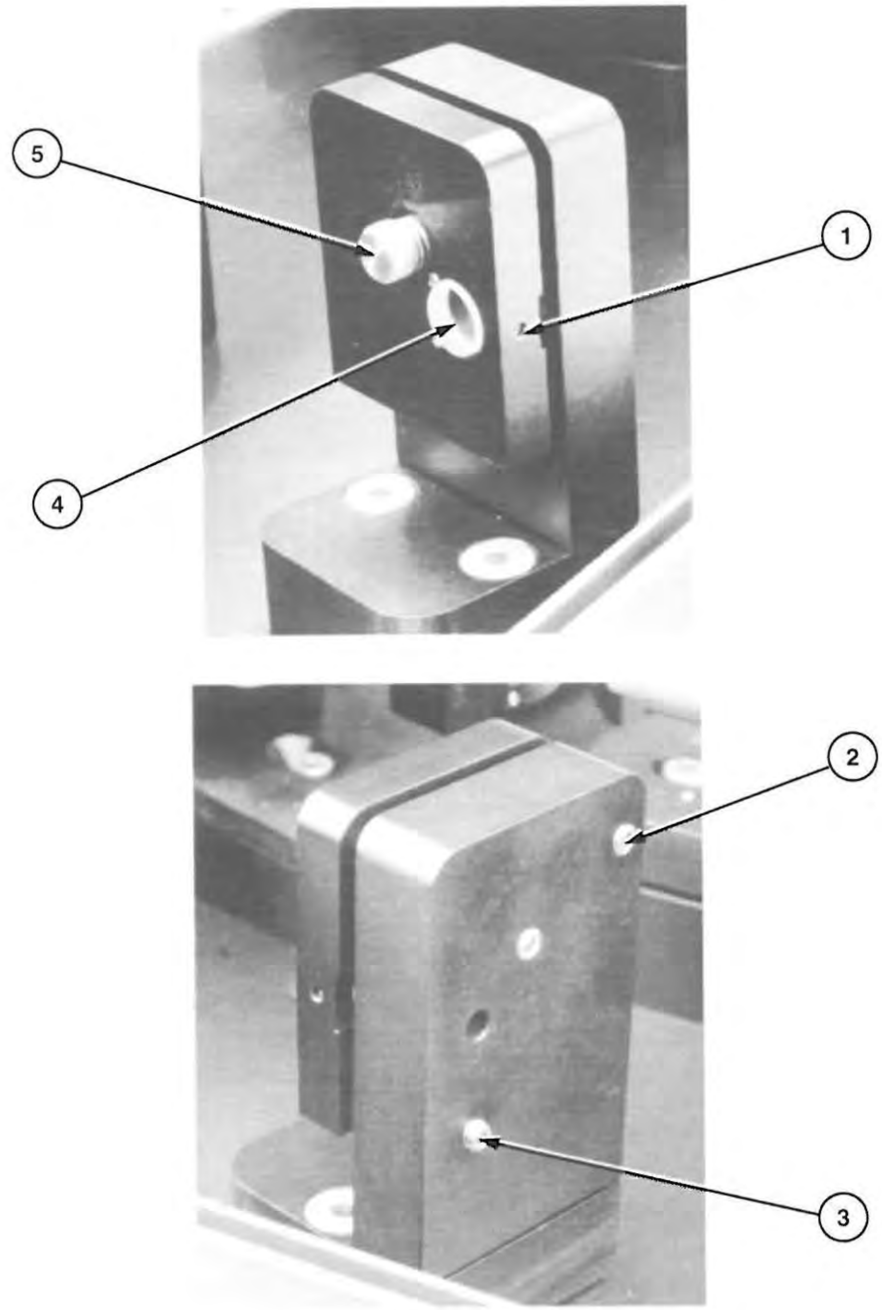


Figure 3-1. Mira Controls and Indicator Locations

Table 3-1. Mira Controls and Indicators Locations

DESIGNATION	CALLOUT	DESCRIPTION	REFERENCE FIGURE
BRF	5	Birefringent Filter	3-7
BS1 - BS4	20	Beamsplitters 1 through 4	3-10, 3-16
Crystal	6	Titanium:sapphire crystal	3-3
GTI	14	Gires-Tournois Interferometer	3-18
L1	8	Lens 1	3-14
M1	1	Output coupler	3-4, 3-10
M2	7	Flat cavity mirror	3-8
M3	3	Flat cavity mirror	3-4
M4	13	Curved mirror	3-3, 3-17
M5	16	Curved mirror	3-3, 3-5
M8	12	Flat mirror (auxiliary cavity)	3-2
M9	19	Flat mirror	3-19
M10	17	Flat mirror	3-6
P0	11	Pump fold mirror	3-10
P1 - P4	9	Pump optics 1 through 4	3-9
Slit	2	——	3-4
Starter	4	——	3-15
——		Controller	3-11, 3-12
——	10	Laser head interface panel	3-14
——	15	Cooling water lines	3-3
——	18	Cavity length control	3-10, 3-16
——	21	Head board	3-10

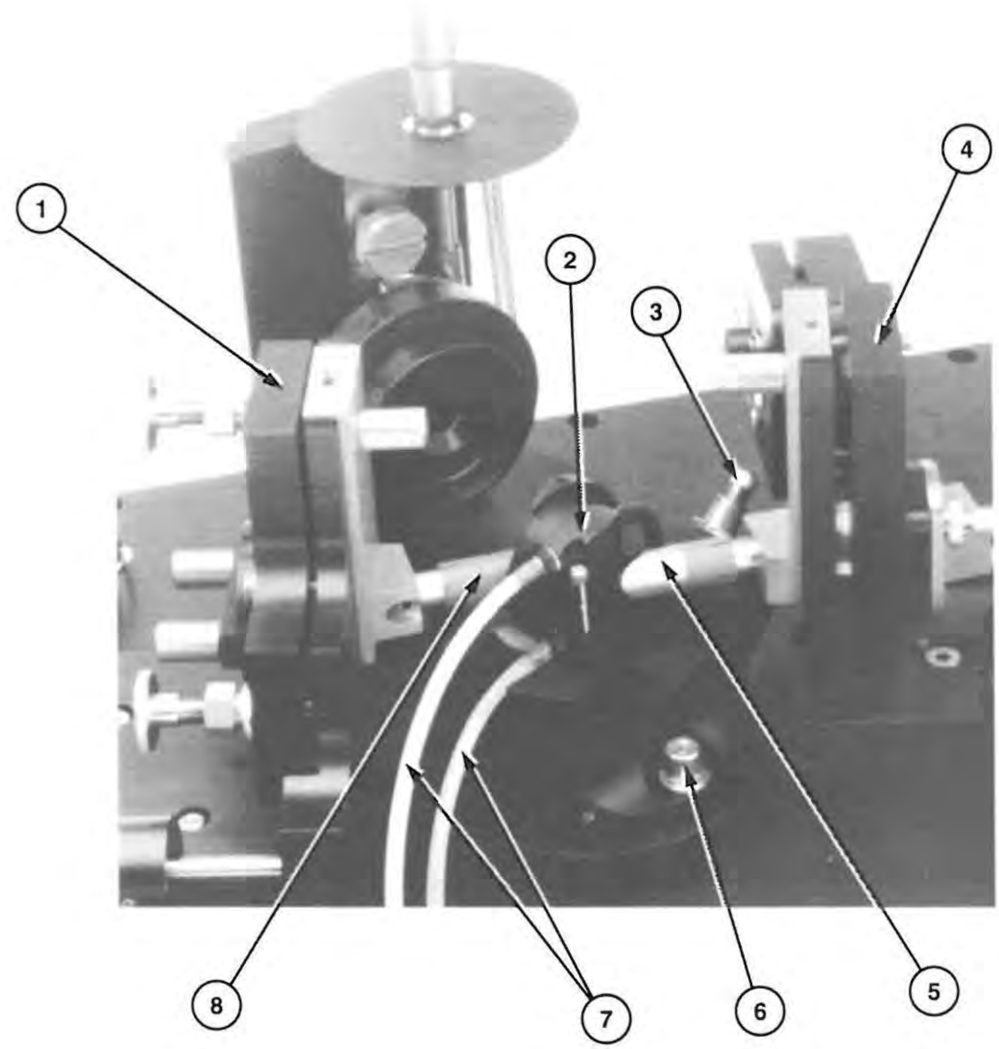


1. M8 optic setscrew
2. M8 horizontal tilt angle control
3. M8 vertical tilt angle control
4. M8 optic
5. Tensioning screw for M8 horizontal and vertical tilt angle controls

Figure 3-2. M8 Controls

Table 3-2. M8 Controls

CONTROL	FUNCTION
M8 optic	Flat folding mirror located in the auxiliary cavity.
M8 optic setscrew	Secures M8 optic in the optic mount assembly.
M8 vertical and horizontal tilt angle controls	Steers the pump beam to the M10 optic during initial alignment.
Tensioning screw for M8 horizontal and vertical tilt angle controls	Determines the amount of pressure required to adjust M8 vertical and horizontal tilt angle controls. This adjustment is performed at the factory and no further adjustments are necessary.



1. M5 optic mount assembly (refer to Figure 3-5)
2. Titanium:sapphire crystal assembly
3. Titanium:sapphire crystal assembly face normal adjustment
4. M4 optic mount assembly (refer to Figure 3-17)
5. Beam tube assembly (M4/crystal)
6. Titanium:sapphire crystal translation adjust fastening screw
7. Cooling water lines
8. Beam tube assembly (M5/crystal)

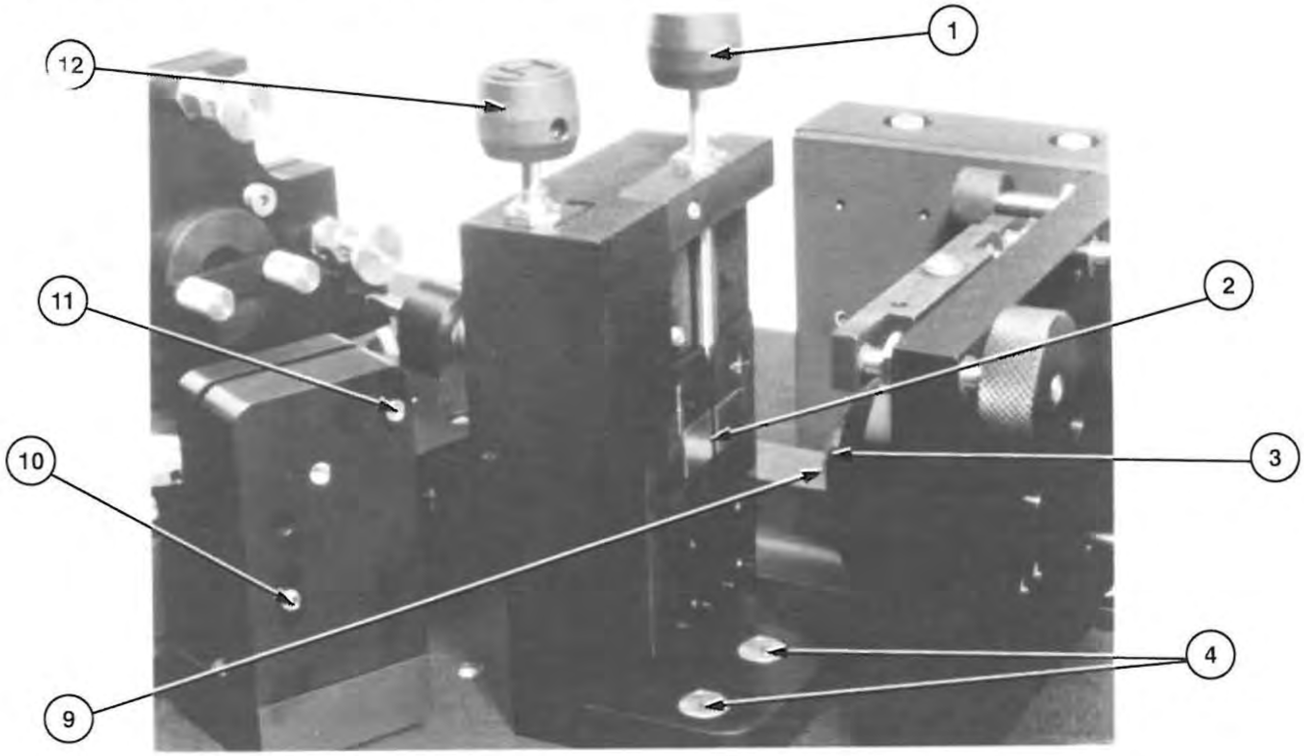
Note: Refer to Figure 3-5 for additional M5 controls.

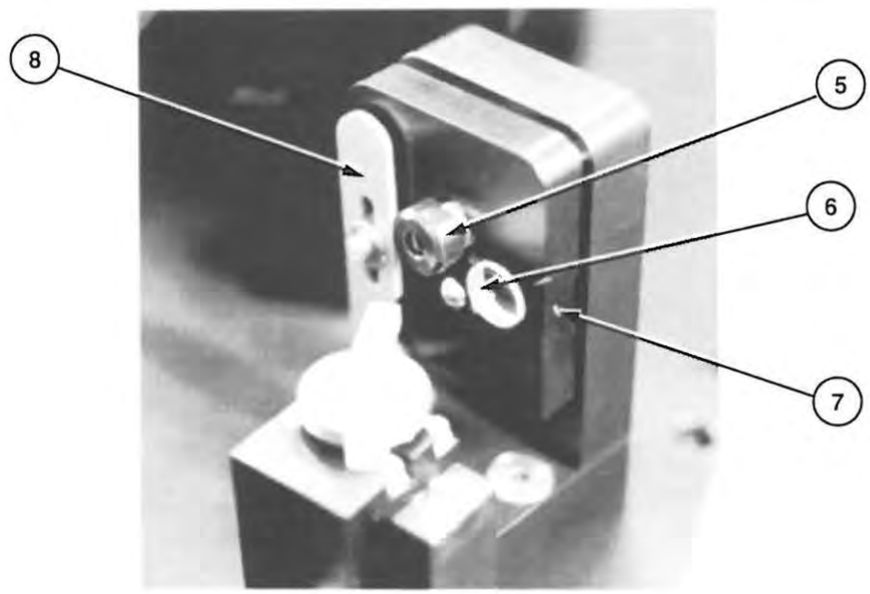
Refer to Figure 3-17 for additional M4 controls.

Figure 3-3. Titanium:Sapphire Crystal Assembly/M5 Controls

Table 3-3. Titanium:Sapphire Crystal Assembly/M5 Controls

CONTROL	FUNCTION
Cooling water lines	Provides cooling water flow to the crystal. Cooling water requirements and recommendations are discussed in Chapter Five. The upper line is the water inlet.
M5 optic assembly	10 cm front surface mount optic assembly.
Titanium:sapphire crystal assembly	The titanium:sapphire crystal is the gain medium for the Mira laser. The crystal assembly includes the crystal mount.
Titanium:sapphire crystal assembly face normal adjustment	Allows face normal adjustment of the titanium:sapphire crystal. This is a factory adjustment and should not be modified after installation unless crystal is replaced.
Titanium:sapphire crystal translation adjust fastening screw.	Two Allen head screws allow centering the crystal with respect to the pump beam. Normally, these screws are not adjusted during operation or maintenance. Incorrect adjustment could result in damage to the crystal. Perform this adjustment only when specifically directed by a procedure in this manual.
M4 optic assembly	10 cm front surface mount optic assembly



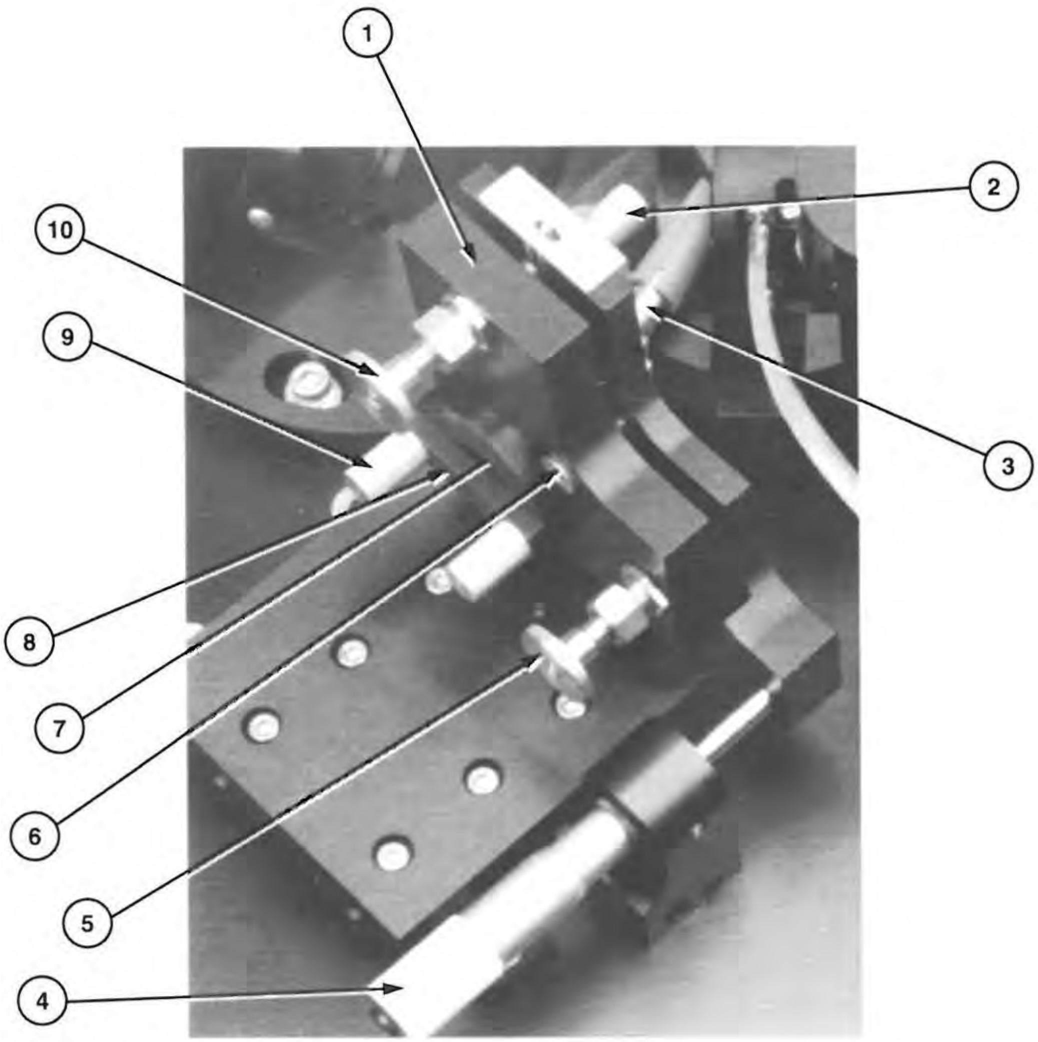


1. Slit width control
2. Slit
3. M1 optic setscrew
4. Slit assembly mounting screws
5. M3 tensioning screw
6. M3 optic
7. M3 optic setscrew
8. M3 alignment aperture
9. M1 optic (Refer to Figure 3-10)
10. M3 vertical tilt angle control
11. M3 horizontal tilt angle control
12. Slit horizontal translation adjustment

Figure 3-4. Slit Assembly/M1/M3 Controls

Table 3-4. Slit Assembly/M3 Controls

CONTROL	FUNCTION
Slit	The slit produces a higher loss in the cavity for CW vs modelocked operation.
Slit horizontal translation adjustment	Allows horizontal translation of the slit to center the slit on the beam.
Slit width control	Controls the width (horizontal opening) of the slit. Clockwise rotation opens the slit. Counterclockwise rotation closes the slit. The width of the slit is larger (opened) during initial alignment in CW operation and is smaller during mode locked operation.
M3 vertical and horizontal tilt angle controls	Allows vertical and horizontal tilt angle adjustment of optic M3 during alignment.
M3 optic	Flat optic in the main cavity.
M3 tensioning screw	Determines the amount of pressure required to adjust M3 vertical and horizontal tilt angle controls. This adjustment is performed at the factory and no further adjustments are necessary.
M3 alignment aperture	The alignment aperture is shown in Figure 3-4 in the open position (out of the beam path) which is the normal operating position. During full alignment, the aperture is positioned over the optic to allow steering the fluorescent spot (or beam) into the aperture.
M3 optic setscrew	Secures M3 optic in the optic mount assembly.
Slit assembly mounting screws	Secures slit assembly to baseplate.



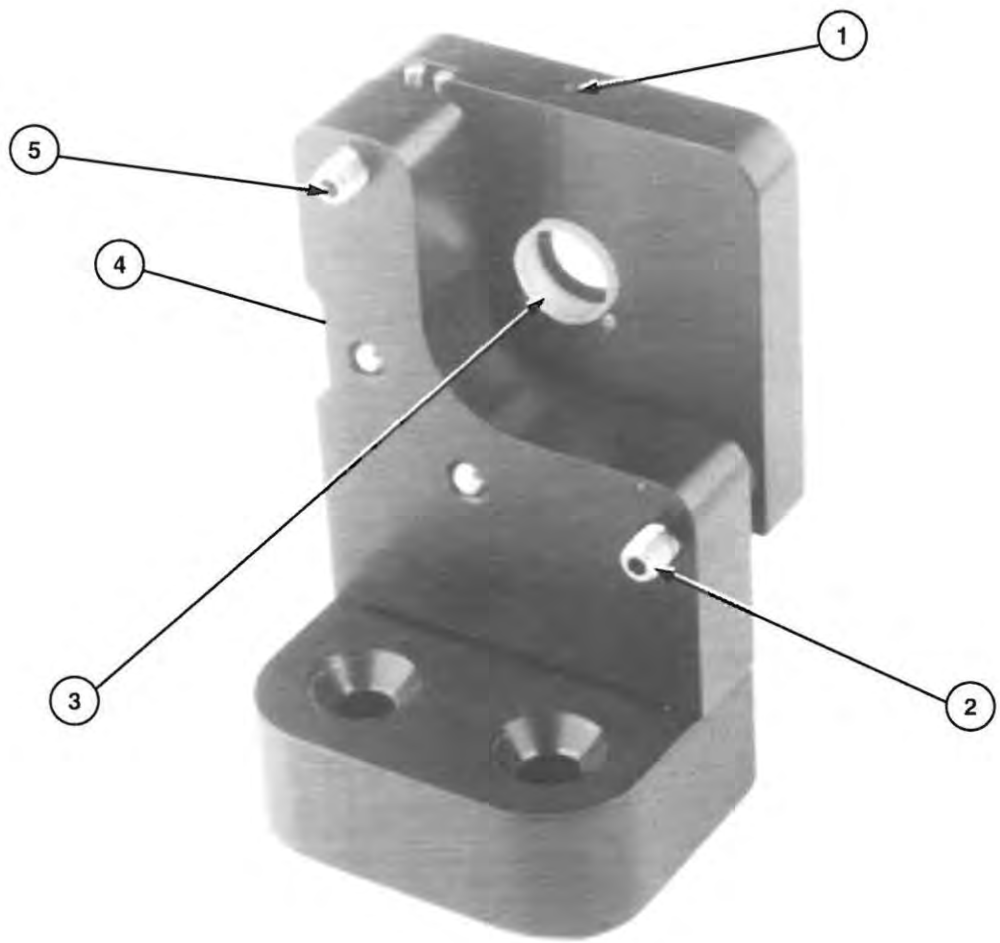
1. M5 optic mount assembly
2. Knurled thumbscrew (beam tube assembly)
3. Beam tube assembly M5/crystal
4. M5 micrometer adjustment
5. M5 horizontal tilt angle adjustment
6. M5 tensioning screw
7. M5 optic (not visible in figure)
8. Beam block
9. M5 mirror retaining thumbscrews (2)
10. M5 vertical tilt angle adjustment

Note: Refer to Figure 3-3 for addition M5 controls.

Figure 3-5. M5 Controls

Table 3-5. M5 Controls

CONTROL	FUNCTION
M5 optic	Front surface mount 10 centimeter radius optic in the main cavity.
M5 micrometer adjustment	Adjusts the distance (D2) between M5 and the titanium:sapphire crystal. This adjustment is normally verified during initial installation. At that time, the micrometer reading is recorded.
M5 horizontal and vertical tilt angle adjustment	Allows horizontal and vertical tilt angle adjustment of the fluorescent spot (or beam) during alignment. The results can be seen on M8 after BP1 has been translated out of the beam path.
M5 mirror retaining thumbscrews (2)	Secures the M5 optic assembly in the mount. Normally, M5 should only be removed for optic replacement. M5 can be cleaned in place.
Beam tube assembly M5/crystal	Help confine stray reflections from the crystal assembly.
Knurled thumbscrew (beam tube assembly)	Secures the M5 beam tube to the mount. Must be completely removed for M5 and titanium:sapphire crystal cleaning.

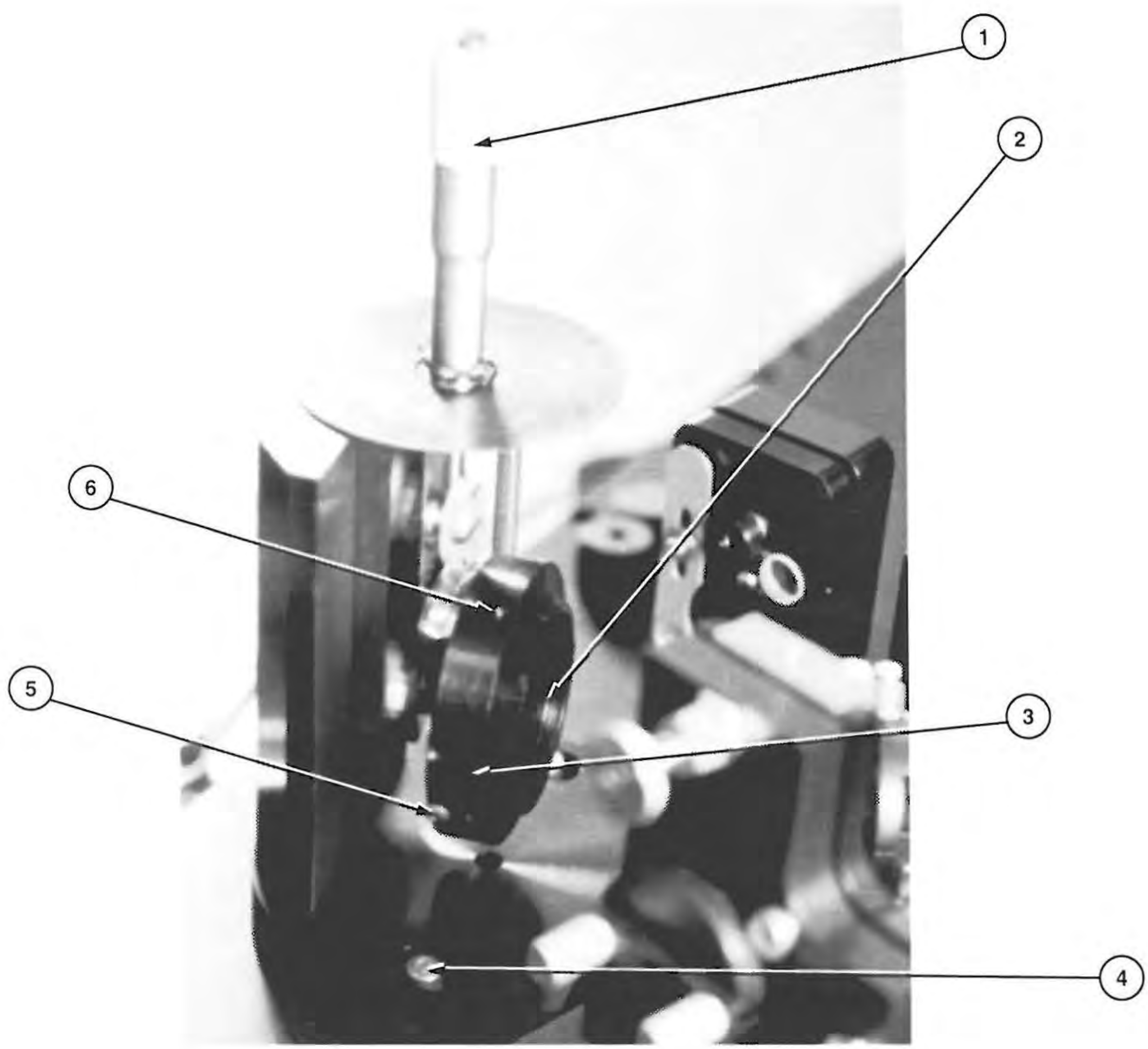


1. M10 optic setscrew
2. M10 horizontal tilt angle adjustment
3. M10 optic (coated surface shown)
4. M10 tensioning screw (not visible)
5. M10 vertical tilt angle adjustment

Figure 3-6. M10 Controls

Table 3-6. M10 Controls

CONTROL	FUNCTION
M10 optic	Flat mirror in the cavity.
M10 horizontal and vertical tilt angle adjustment	Allows horizontal and vertical adjustment of the fluorescent spot onto GTI (or beam) during alignment.
M10 optic setscrew	Secures M10 optic in the optic mount assembly.
M10 tensioning screw	Determines the amount of pressure required to adjust M10 vertical and horizontal tilt angle controls. This adjustment is performed at the factory and no further adjustments are necessary.

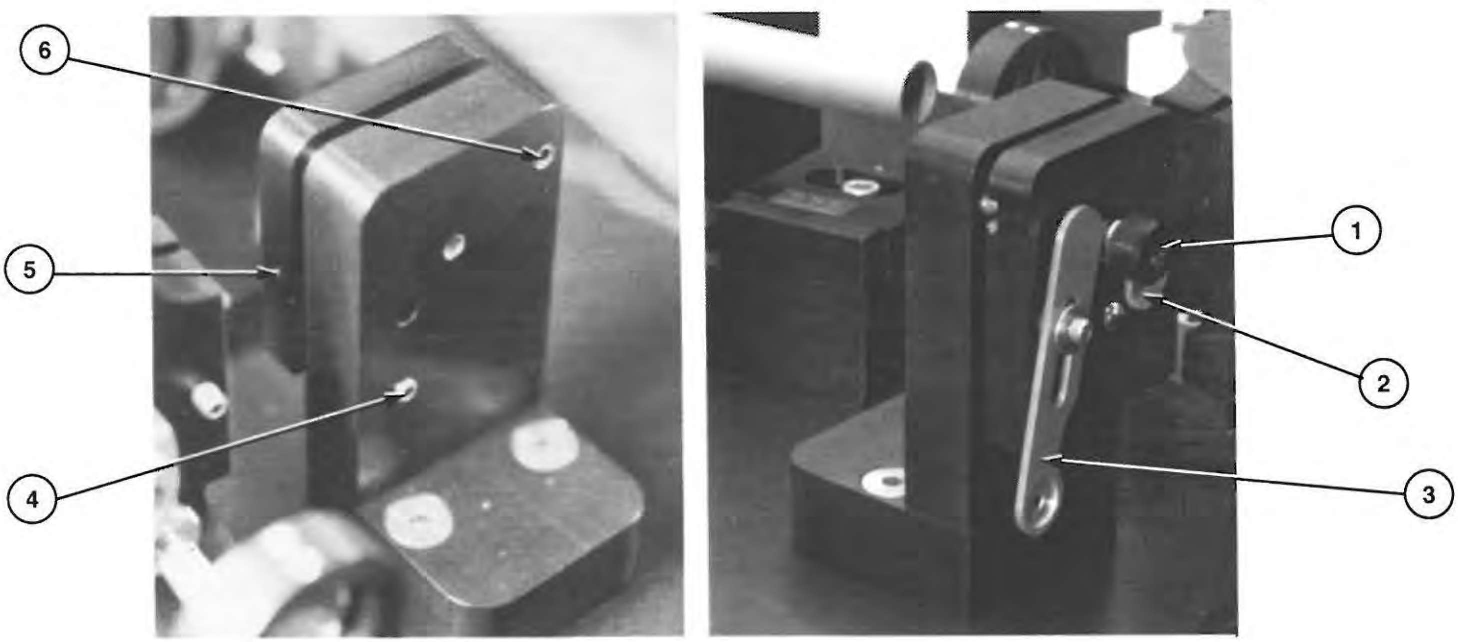


1. BRF micrometer adjust (wavelength tuning)
2. Birefringent filter (BRF)
3. BRF notch
4. BRF Brewster's angle adjustment screws
5. Button head screw
6. BRF setscrew

Figure 3-7. Birefringent Filter Controls

Table 3-7. Birefringent Filter Controls

CONTROL	FUNCTION
Birefringent filter (BRF)	The one plate birefringent filter provides smooth laser cavity tuning within each tuning order. Refer to the tuning chart (supplied with the laser) that provides wavelength vs micrometer setting.
BRF micrometer adjust	Allows for tuning the birefringent filter during initial alignment and during daily operation. A tuning chart that provides wavelength vs micrometer setting is provided with each laser.
BRF Brewster's angle adjustment screws (2)	Loosening the two Allen head screws allows adjusting the BRF for Brewster's angle with respect to the optical path. Used when switching from 1 plate BRF (femtosecond operation) to 3 plate BRF (picosecond operation). This is a factory adjustment and readjustment is not normally required.
BRF notch	The notch when in the "2 o'clock" position (Figure 5-3) generally indicates the primary tuning order. The laser tuning chart (supplied with the system) is the more accurate indication of operating wavelength.
BRF setscrew	Secures the BRF optic holder in place. Normally not adjusted.
Allen head screw	Secures the outer holder to the mount assembly.
Button head screw	Secures the BRF plate and mount to the outer ring. Used to remove BRF.

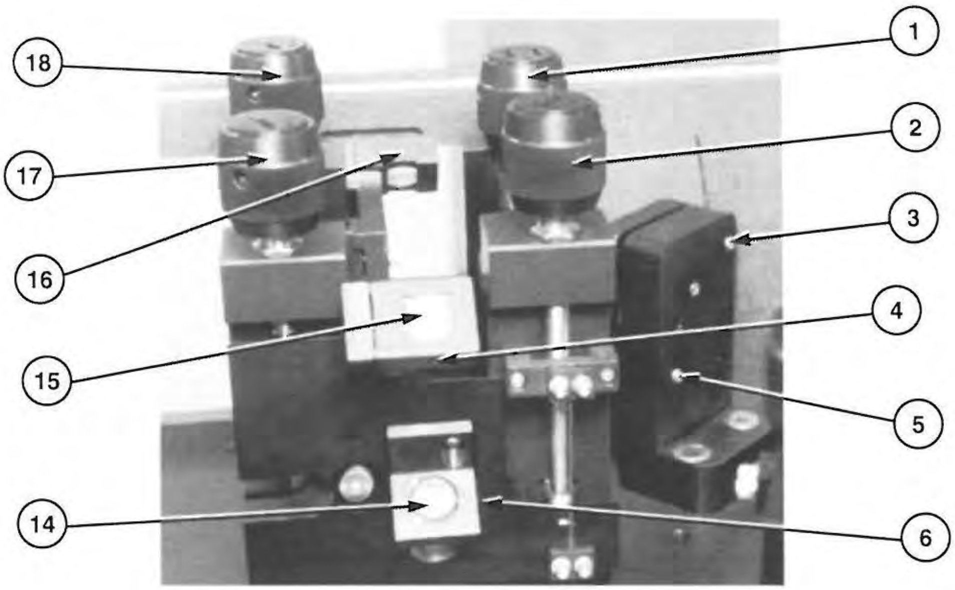


1. M2 tensioning screw
2. M2 optic
3. M2 alignment aperture
4. M2 vertical tilt angle control
5. M2 optic setscrew
6. M2 horizontal tilt angle control

Figure 3-8. M2 Controls

Table 3-8. M2 Controls

CONTROL	FUNCTION
M2 optic	Flat optic in the main cavity.
M2 horizontal and vertical tilt angle control	Allows horizontal and vertical tilt angle adjustment of the fluorescent spot (or beam). Adjustment results can be seen on the output coupler.
M2 tensioning screw	Determines the amount of pressure required to adjust M2 vertical and horizontal tilt angle controls. This adjustment is performed at the factory and no further adjustments are necessary.
M2 alignment aperture	The alignment aperture is shown in Figure 3-9 in the open position (out of the beam path) which is the normal operating position. During full alignment, the aperture is positioned over the optic to allow steering the fluorescent spot (or beam) from the crystal into the aperture and to allow steering the retro-reflection from the output coupler into the aperture.
M2 optic setscrew	Secures M2 optic in the optic mount assembly.



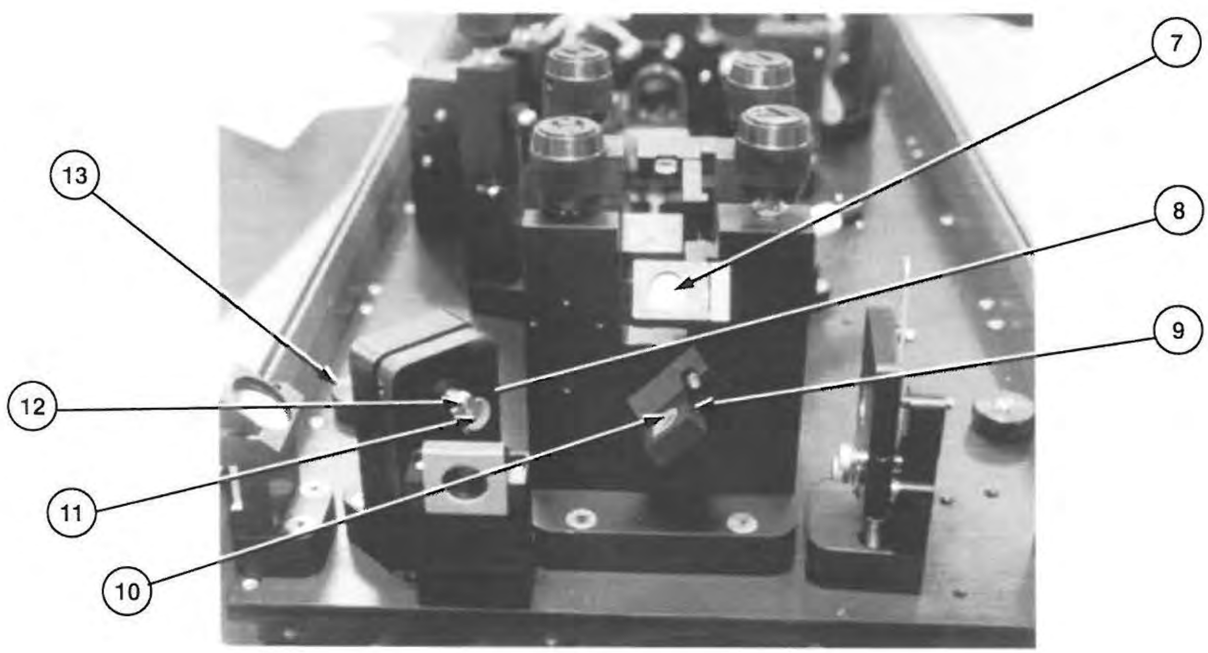


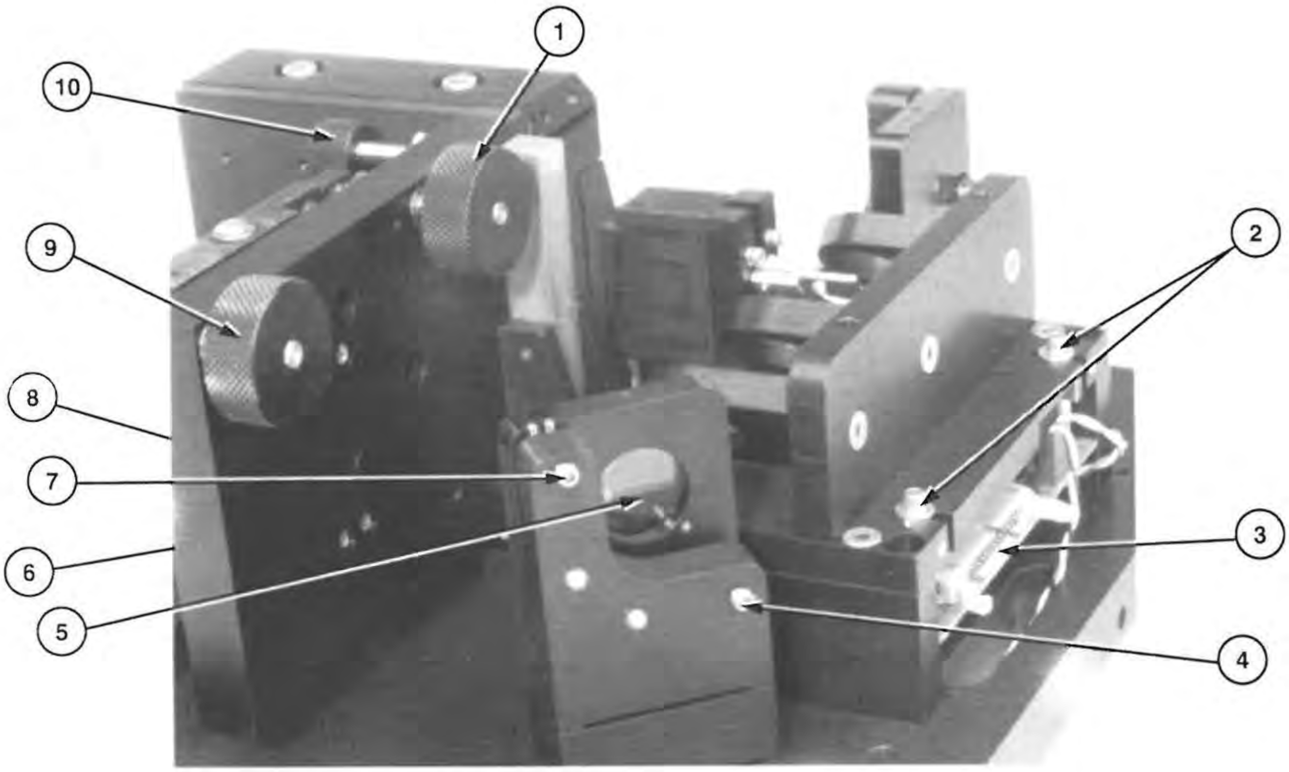
Figure 3-9. Pump Optic Controls

1. P2 horizontal tilt angle control
2. P3/P4 horizontal tilt angle control
3. P0 horizontal tilt angle control
4. P3 optic setscrew
5. P0 vertical tilt angle control
6. P4 optic setscrew
7. P2 pump optic
8. P0 optic setscrew (not visible in photo)
9. P1 optic setscrew
10. P1 pump optic
11. P0 pump optic
12. P0 tensioning screw
13. P4 pump optic
14. P3 pump optic
15. P2 optic setscrew
16. P3/P4 vertical tilt angle control
17. P2 vertical tilt angle control
18. Laser head height and leveling adjustment screws (2)

Figure 3-9. Pump Optic Controls (Continued)

Table 3-9. Pump Optic Controls

CONTROL	FUNCTION
P0 optic	P0 is a pump beam fold mirror that allows straight-in pumping. P0 is not used for left side and right side pumping.
P1 through P4 optics	Pump beam steering optics.
P0 horizontal and vertical tilt angle control	Allows horizontal and vertical tilt angle adjustments of pump optic P0. Controls are used only during initial alignment.
P2 horizontal and vertical tilt angle control	Allows horizontal and vertical tilt angle adjustments of pump optic P2. Controls the angle of pump beam with respect to cavity axis. Controls are used during initial alignment.
P3/P4 horizontal and vertical tilt angle control	Allows horizontal and vertical tilt angle adjustments of fourth and fifth pump optics P3 and P4. Controls lateral position of pump beam with respect to cavity axis. Controls are used during alignment and power optimization.
P0 through P4 setscrews	Secures P0 through P4 pump optics to their respective mounts.
P0 tensioning screw	Determines the amount of pressure required to adjust P0 vertical and horizontal tilt angle controls. This adjustment is performed at the factory and no further adjustments are necessary.
Laser head height and leveling adjustment screws (2)	The height and leveling adjustments are performed at the factory. No further adjustments are required. Allows leveling and adjusting the laser head. Height adjustment and height leveling is accomplished by loosening the knurled retainer, then using a screwdriver to adjust the screw.

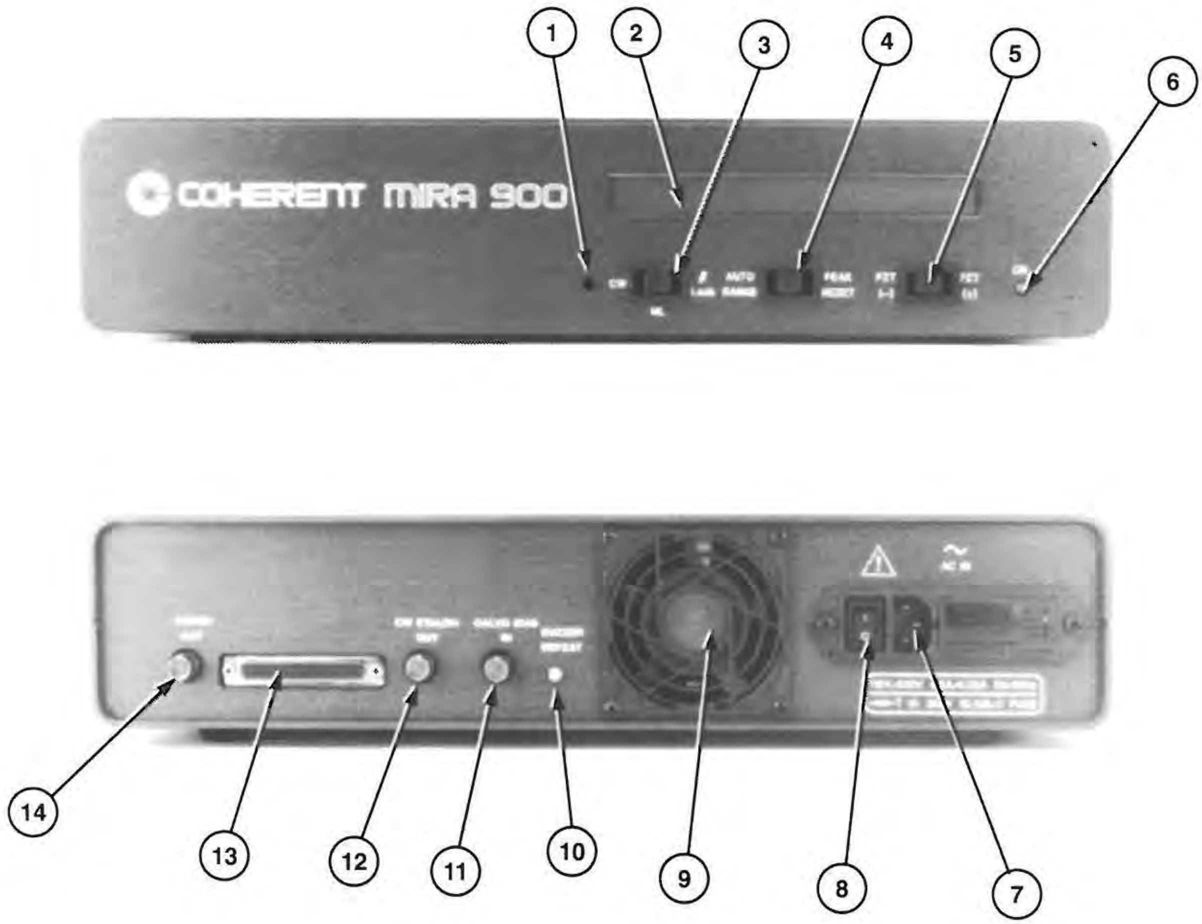


1. Output coupler (M1) horizontal tilt angle control
2. Screws (4) securing headboard
3. Head board
4. Beamsplitter horizontal tilt angle control
5. Beamsplitter BS1
6. M1 optic (refer to Figure 3-4)
7. Beamsplitter vertical tilt angle control
8. M1 setscrew (refer to Figure 3-4)
9. Output coupler (M1) vertical tilt angle control
10. Cavity length adjustment

Figure 3-10. Output Coupler/Beamsplitter/Head Board/Cavity Length Controls

Table 3-10. Output Coupler/Beamsplitter/Head Board/Cavity Length Controls

CONTROL	FUNCTION
Output coupler M1	Partially transmitting cavity end mirror that allows a portion of the output beam to exit the cavity.
Output coupler (M1) vertical and horizontal tilt angle controls	Allows horizontal and vertical tilt angle adjustment of output coupler to align the cavity.
Head board	Three photodiodes and circuitry to process information from the three photodiodes are located on this board. The photodiodes provide the following: • A sync output to allow synchronizing the output pulse to an experiment. Input from beamsplitter BS2 (refer to Figure 3-20). • CW content information for display on the controller. Input from beamsplitter BS4 (refer to Figure 3-20). • Average output power for display on the controller. Input from beamsplitter BS3 (refer to Figure 3-20).
Beamsplitter (BS1) horizontal and vertical tilt angle controls	Allows positioning of the beamsplitter to steer a portion of the output beam onto the three beamsplitters (Figure 3-20, items 1, 3, and 4) that provide input to the photodetectors located on the head board.
Screws (4)	Secures the head board to the laser head.
Beamsplitter BS1	Provides a small portion of the output beam to the photodetectors on the head board via beamsplitters BS2 through BS4.
M1 optic setscrew	Secures M1 optic in the optic mount assembly.

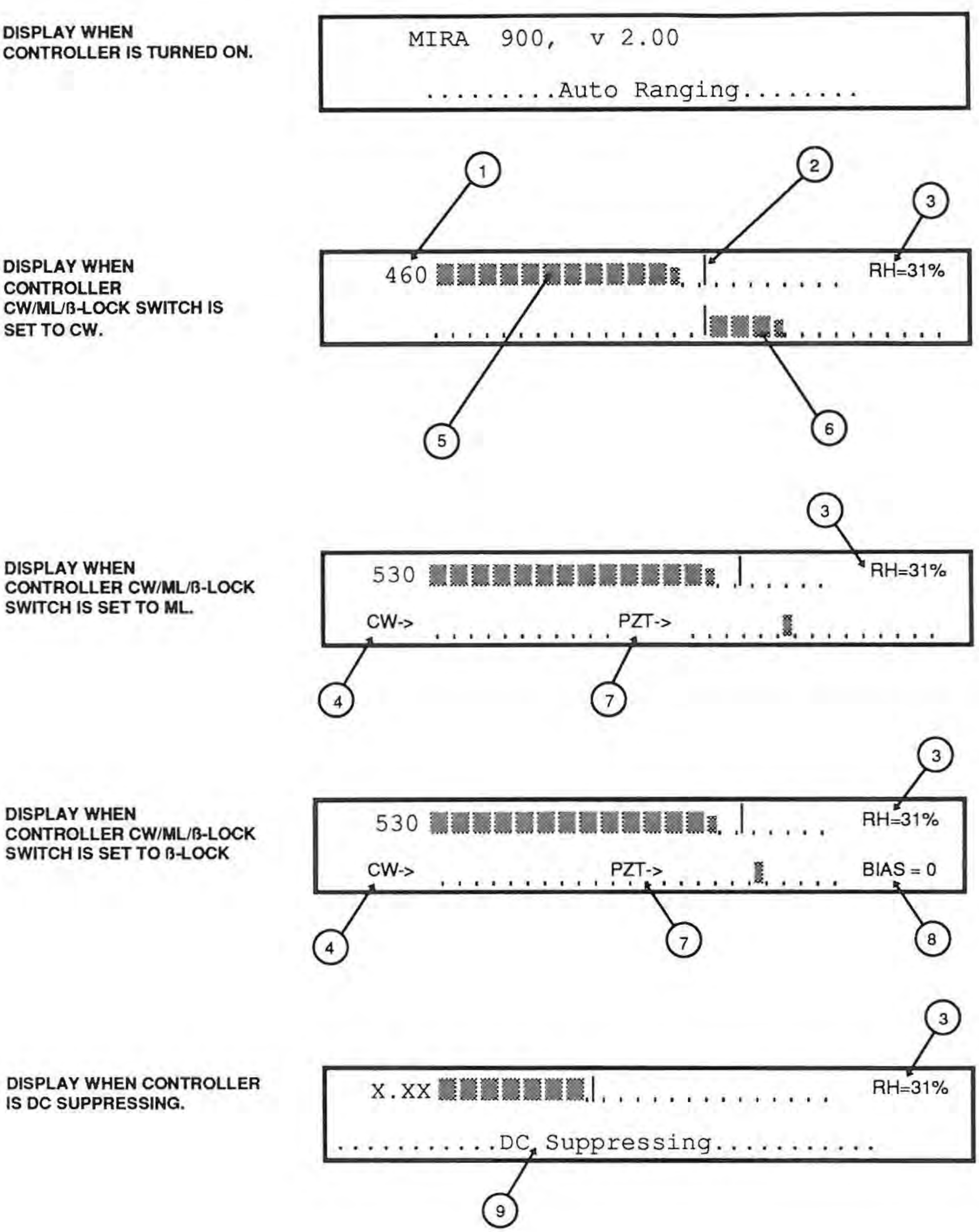


1. View angle adjust
2. LCD display
3. CW/ML/β-Lock select switch
4. AUTO RANGE / PEAK RESET select switch
5. PZT (-) / PZT (+) select
6. ON indicator LED
7. AC In
8. ON/OFF Switch
9. Fan
10. BUZZER DEFEAT switch
11. GALVO BIAS IN BNC connector
12. CW ETALON OUT BNC connector
13. Head board connector
14. POWER OUT BNC connector

Figure 3-11. Controller Controls and Indicators

Table 3-11. Controller Controls and Indicators

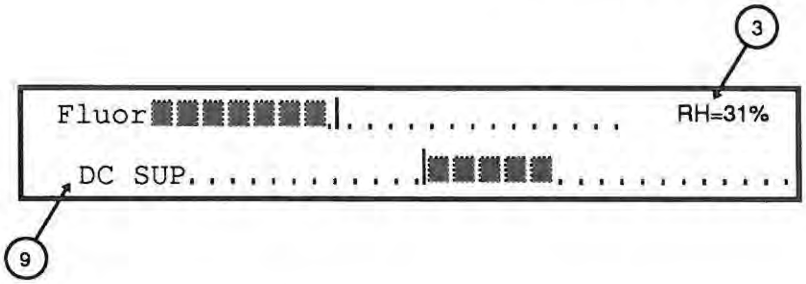
CONTROL	FUNCTION
CONTROLLER FRONT PANEL	
LCD display	This 2 line 80 character LCD display provides cavity and diagnostic information relating to the Mira. Refer to Figure 3-13 for an explanation of the displays.
ON indicator	Indicates that the Mira controller has been turned on.
AUTO RANGE	Allows the power display to automatically switch (auto range) to the next higher power scale. The controller produces an audible buzzer when the display autoranges to a higher scale. If desired, the buzzer can be turned off using the BUZZER DEFEAT on the controller rear panel. The power display will not autorange to a lower scale. The switch must be toggled to the AUTO RANGE position to change to a lower scale.
PEAK RESET	The toggle position (switch does not remain in the PEAK RESET position when released) allows the peak marker on the display to be reset to current power level.
View angle adjust	This adjustment allows the LCD display to be adjusted for the best viewing angle.
CW/ML/β-Lock select switch	Allows selection between ML, β-Lock and CW modes.
PZT (–)/PZT (+) select switch	Allows the voltage on the GTI to changed. In the ML mode this switch adjusts the PZT voltage directly. In the β-Lock mode it adjusts the servo lock-point (which varies the PZT voltage).
CONTROLLER REAR PANEL	
POWER OUT BNC connector	Analog output proportional to average power.
CW ETALON OUT BNC connector	Provides an analog voltage output related to the CW component.
GALVO BIAS IN BNC connector	Provides external control of the starter galvo to make small changes to the cavity length.
Head board connector	Provides an interface connection to the head board located in the Mira laser head.
Buzzer defeat	Allows the buzzer to be turned off or on. The buzzer indicates that the power display has automatically changed to a higher scale as dictated by the autoranging feature.
ON/OFF Switch	Applies 115 (or 230) volts to the Mira controller.
AC In	AC power cord connector.
Voltage select switch	Allows either 115 or 230 volts AC operation. Position is set during installation only by a Coherent service engineer.
Fan	Provides air cooling for the controller.



Note: The controller beeps once when autoranging.
The controller beeps three times upon startup if a RAM error occurred.

Figure 3-12. Controller Displays (1 of 2)

DISPLAY WHEN CONTROLLER IS SET TO CW AND MIRA IS NOT LASING.

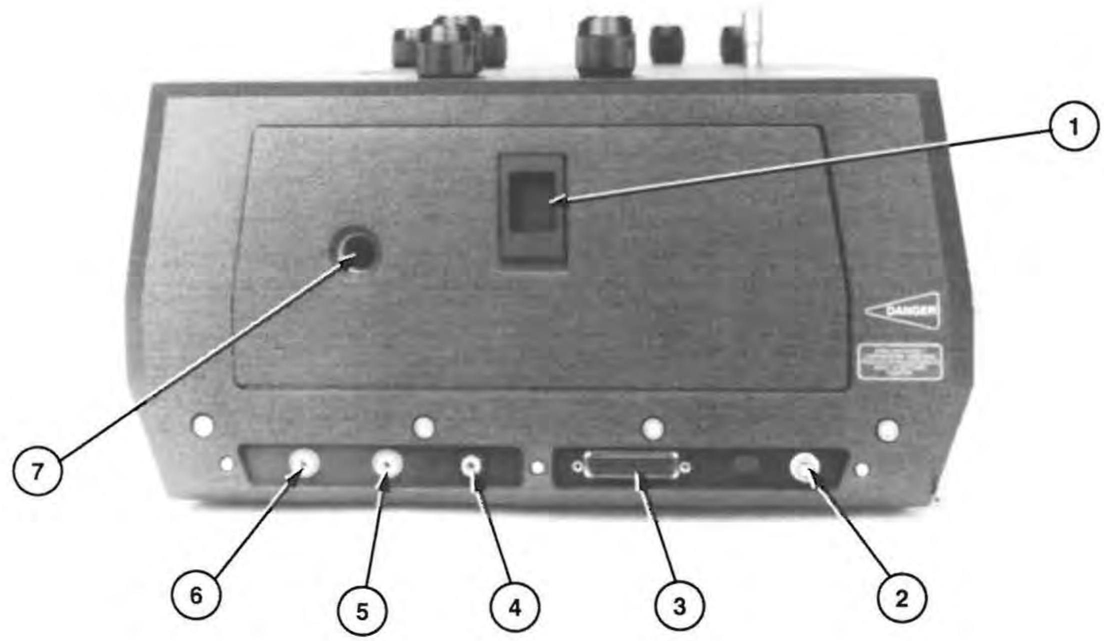


Note: The controller beeps once when autoranging.
The controller beeps three times upon startup if a RAM error occurred.

Figure 3-12. Controller Displays (2 of 2)

Table 3-12. Controller Displays

KEY	DESCRIPTION
1	The count is proportional to the output power at normal output levels.
2	Peak power marker reflecting the maximum power achieved since last peak reset. The marker can be reset by toggling the AUTO RANGE/PEAK RESET switch to PEAK RESET.
3	RH indicates the relative humidity in the laser cavity.
4	Bar graph displays average power output.
5	Expanded average power display, showing change in power since the last AUTO RANGE or PEAK RESET. When the AUTO RANGE/PEAK RESET switch is toggled to AUTO RANGE, the expanded average power display resets without resetting the peak indicator. Power decreases and increases are indicated by an outlined bar.
6	PZT indicates the voltage applied to the GTI PZTs. ML range is 2 to 14 Volts and β-Lock is 0 to 28 Volts.
7	Displays CW component in output beam, usually indicating that the slit width must be decreased.
8	Bias indicates the lock point on the GTI fringe. The range for the bias is –127 to +127.
9	DC Suppression increases the display sensitivity. Maximum sensitivity is desired when using the display to observe fluorescence. The controller DC Suppression feature can only be activated when DC SUP is displayed in the lower left corner of the display. See Key 2. In this mode it may be necessary to reduce room lighting.
10	Fluor indicates the laser is not lasing and that the fluorescence is being seen by the detectors.
11	DC SUP indicates that DC Suppression can be initiated by holding down the AUTO RANGE/ PEAK RESET switch in the AUTO RANGE position for at least 2 seconds. DC SUP will appear when the Mira is not lasing, the controller CW/ML switch is set to CW, and the AUTO RANGE/PEAK RESET switch is toggled to AUTO RANGE.

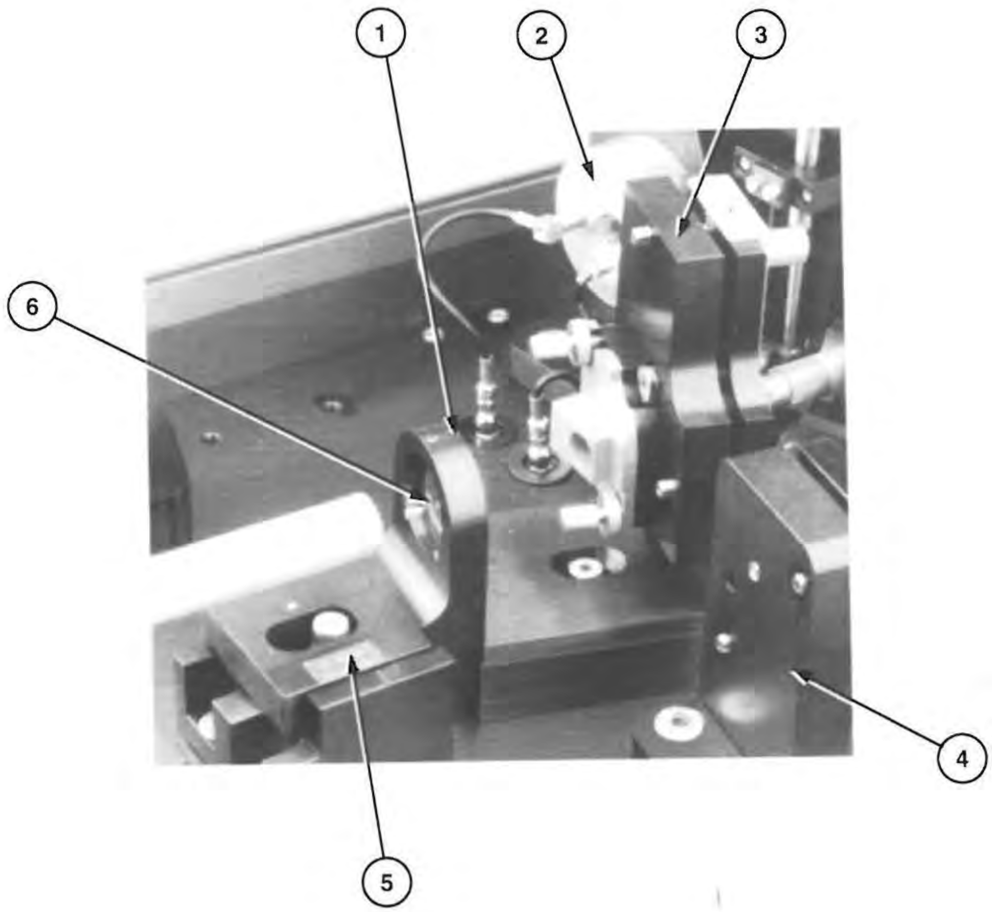


1. Cover latch
2. Fast diode output (sync out)
3. Laser head connector
4. Nitrogen purge connector
5. Water IN/OUT connector
6. Water IN/OUT connector
7. Pump beam input aperture

Figure 3-13. Laser Head Rear Interface Connectors

Table 3-13. Laser Head Rear Interface Connectors

CONTROL	FUNCTION
Laser head connector	Provides and interface connection to the head board 24 pin connector located on the rear of the controller.
Fast diode output	Output for synchronizing external equipment with the Mira output pulse. This output can also be used to monitor the output pulse with an oscilloscope. Refer to Figure 5-3.
Nitrogen purge	Tubing connector for a nitrogen purge for the Mira laser head. Do not connect water to this line.
Water connectors	Hose connectors for the crystal cooling water needed.
Cover latch	Allows the laser head rear cover to be opened.
Input aperture (3)	The input aperture is a Brewster window that allows the pump beam to enter the laser head while allowing the covers to provide a tight seal. There are two additional apertures for left side and right side pumping. The input aperture illustrated on the end cover is used when the Mira is configured for straight in pumping.

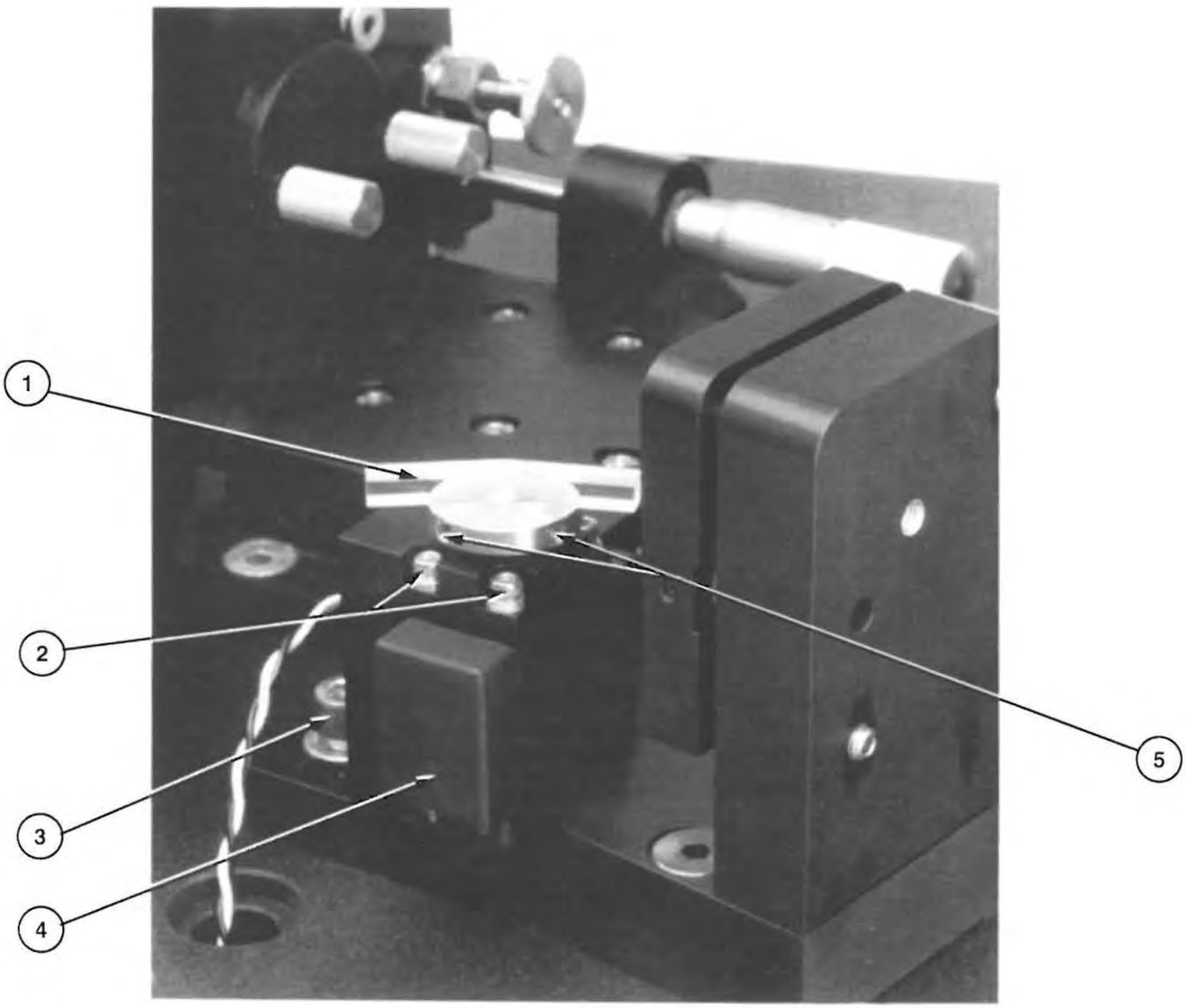


1. L1 optic setscrew
2. Focusing lens L1
3. L1 mount index marker
4. GTI mount assembly (ref. Figure 3-18)
5. M4 mount assembly (ref. Figure 3-17)
6. M2 mount assembly (ref. Figure 3-8)

Figure 3-14. Focusing Lens L1 Controls

Table 3-14. Focusing Lens L1 Controls

CONTROL	FUNCTION
Focusing lens L1	Focuses the pump beam onto the crystal.
L1 optic setscrew	Secures the L1 optic in the L1 mount.
L1 mount index marker	Indicates the position of the L1 mount during factory alignment. This is not a user adjustment.

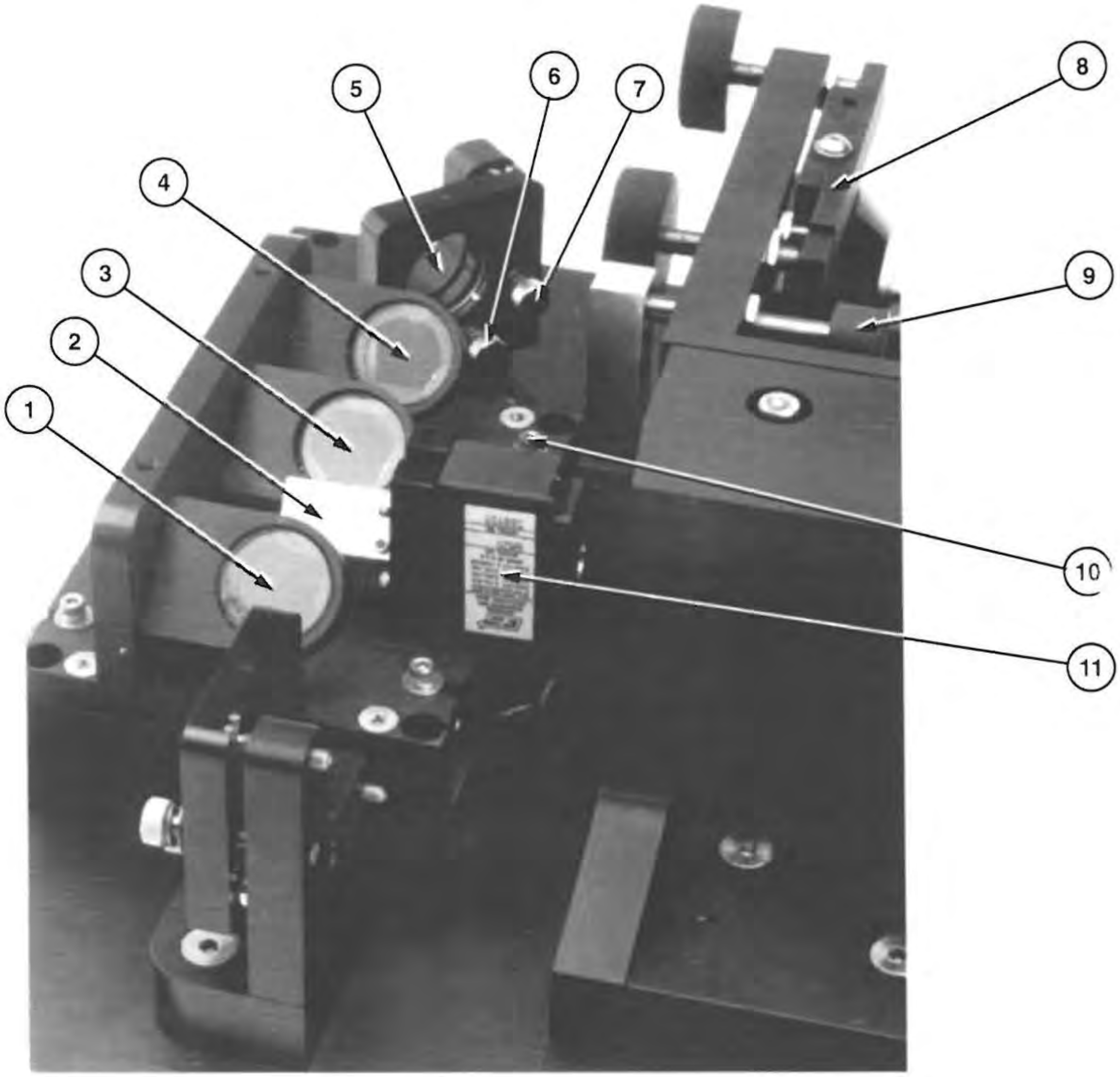


1. Starter assembly butterfly
2. Allen head screws (4)
3. Starter assembly Allen head screw
4. Galvo
5. Setscrews (2)

Figure 3-15. Starter Assembly

Table 3-15. Starter Assembly

CONTROL	FUNCTION
Starter assembly butterfly	The butterfly mounted on the starter assembly initiates modelocked operation. The butterfly oscillates when a drive signal is applied to the starter assembly galvo. The oscillation causes rapid small changes to the cavity length. The "DC" position of the butterfly can also be slightly changed by applying an external voltage to the GALVO BIAS BNC connector on the rear of the controller.
Setscrews	Secures the butterfly and butterfly mount to the galvo shaft. Not normally adjusted.
Galvo	Causes the butterfly to oscillate when activated by a drive signal from the controller which continuously monitors the laser output beam.
Starter assembly Allen head screw	Allows adjustment of the starter assembly so that the butterfly is positioned at Brewster's angle with respect to the beam path when not activated.

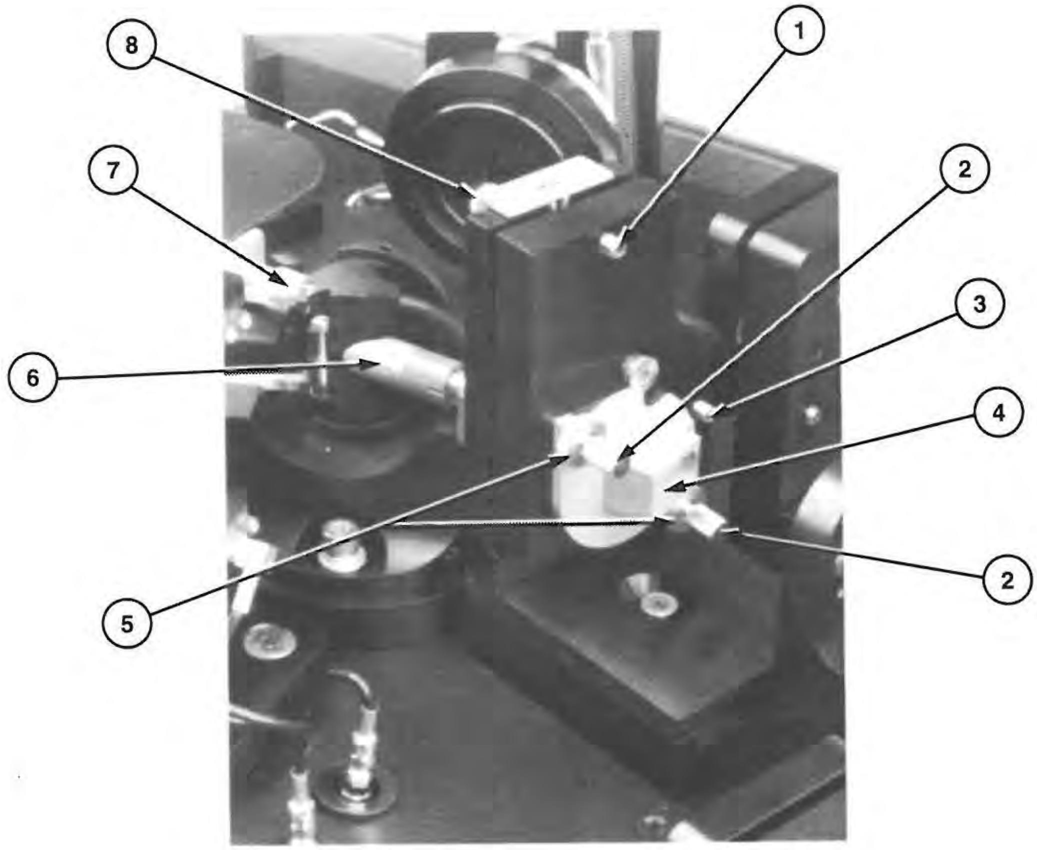


1. Beamsplitter BS4
2. Etalon
3. Beamsplitter BS3
4. Beamsplitter BS2
5. Beamsplitter BS1
6. BS1 vertical tension adjust
7. BS1 horizontal tension adjust
8. Output coupler lever arm
9. Cavity length adjustment control
10. Screws (4)
11. Etalon galvo

Figure 3-16. Beamsplitters

Table 3-16. Beamsplitters

CONTROL	FUNCTION
CW beamsplitter BS4	Provides a portion of the output beam to the CW detector located on the head board. The detector provides CW information for display on the controller.
Average power beamsplitter BS3	Provides a portion of the output beam to the average power detector located on the head board. The detector provides average output power information for the controller display.
Beamsplitter for fast photodiode BS2	Provides a portion of the output beam to the fast photo diode located on the head board. The fast photodiode provides a sync output to allow synchronizing the output pulse to an experiment.
Beamsplitter BS1	Provides a small portion of the output beam to the photodetectors on the head board via beamsplitters BS2 through BS4.
Etalon	Provides the CW component information of the output beam to the controller via the CW beamsplitter and photodiode on the laser head board. The presence of CW during normal modelocked operation indicates the slit is not properly adjusted.
Tensioning screws	Determines the amount of pressure required to adjust M9 vertical and horizontal tilt angle controls. This adjustment is performed at the factory and no further adjustments are necessary.
Cavity length adjustment control	Allows adjustment of pulse repetition rate.
Etalon galvo	Causes the etalon to oscillate.
Screws (4)	Secures the galvo to the mount. Not normally adjusted.

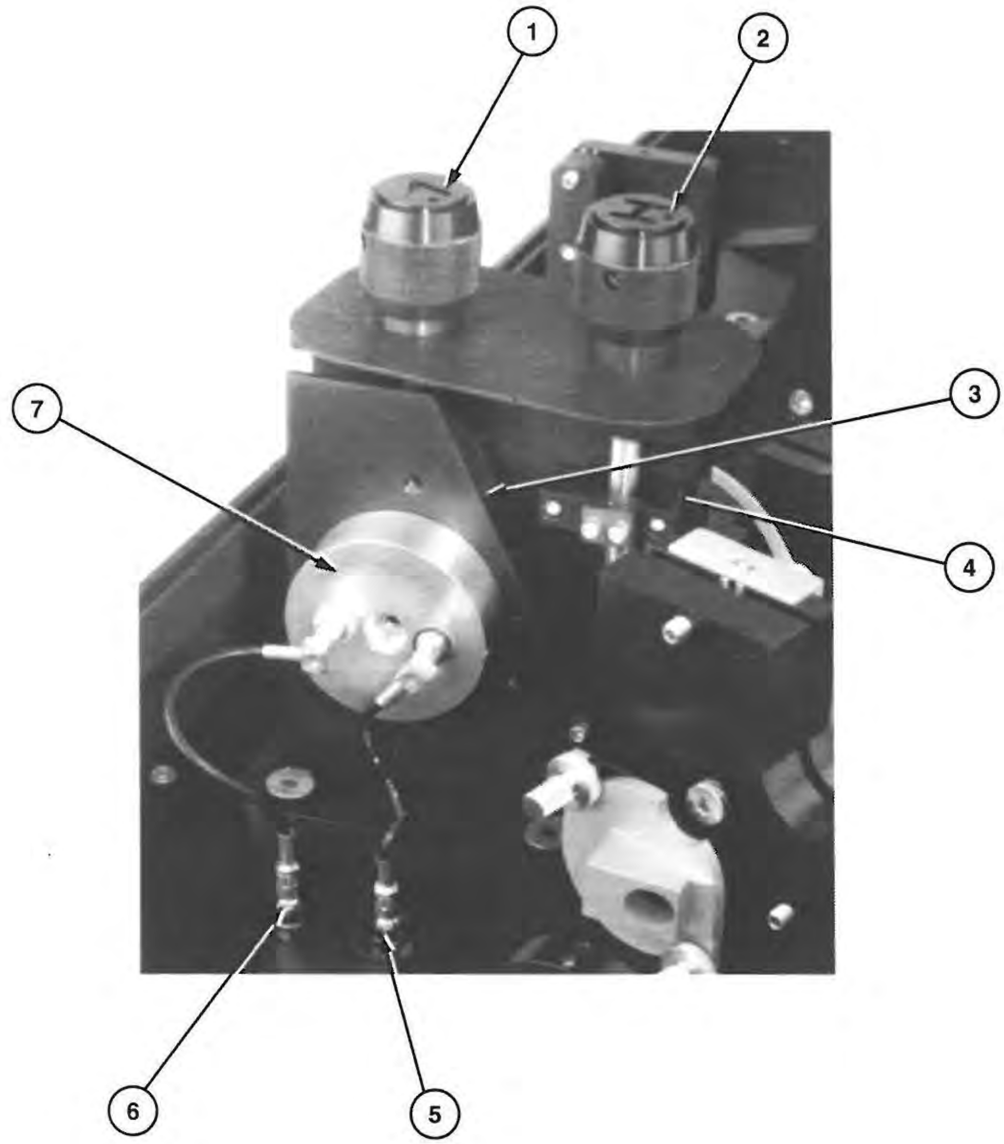


1. M4 vertical tilt angle control
2. M4 optical retaining thumbscrews (2)
3. M4 horizontal tilt angle control
4. M4 beam tube assembly
5. M4 beam tube thumbnuts (2)
6. Beam tube assembly M4/crystal
7. Beam tube assembly M5/crystal
8. Knurled thumbscrew (beam tube assembly)

Figure 3-17. M4 Controls

Table 3-17. M4 Controls

CONTROL	FUNCTION
M4 horizontal and vertical tilt angle controls	Allows horizontal and vertical adjustment of M4 during alignment.
Beam tube assembly M5/crystal	Provides protection of crystal from dust. Confines stray reflections between the crystal and M5. Note the position of the telescoping beam tube. The entire assembly can be removed by loosening the thumbnuts. Removal is unnecessary unless directed by a procedure in this manual.
Beam tube assembly M4/crystal	Provides protection of crystal from dust. Confines stray reflections between crystal and M4. Note the position of the telescoping beam tube. Removal is unnecessary unless directed by a procedure in this manual.
Knurled thumbscrews (beam tube assembly)	Secures the beam tube assembly to their mounts.
M4 optic retaining thumbscrews (2)	Secures the M4 optic assembly in the mount. Normally, these thumbscrews should only be removed for M4 optic replacement. M4 can be cleaned in place.
M4 beam tube assembly	Helps confine stray reflections from M4.
M4 beam tube thumbnuts	Secures the M4 beam tube assembly to the mount. These thumbnuts should be loosened to remove beam tube to clean rear surface of M4. Be careful not to loosen M4 optic retaining thumbscrews.

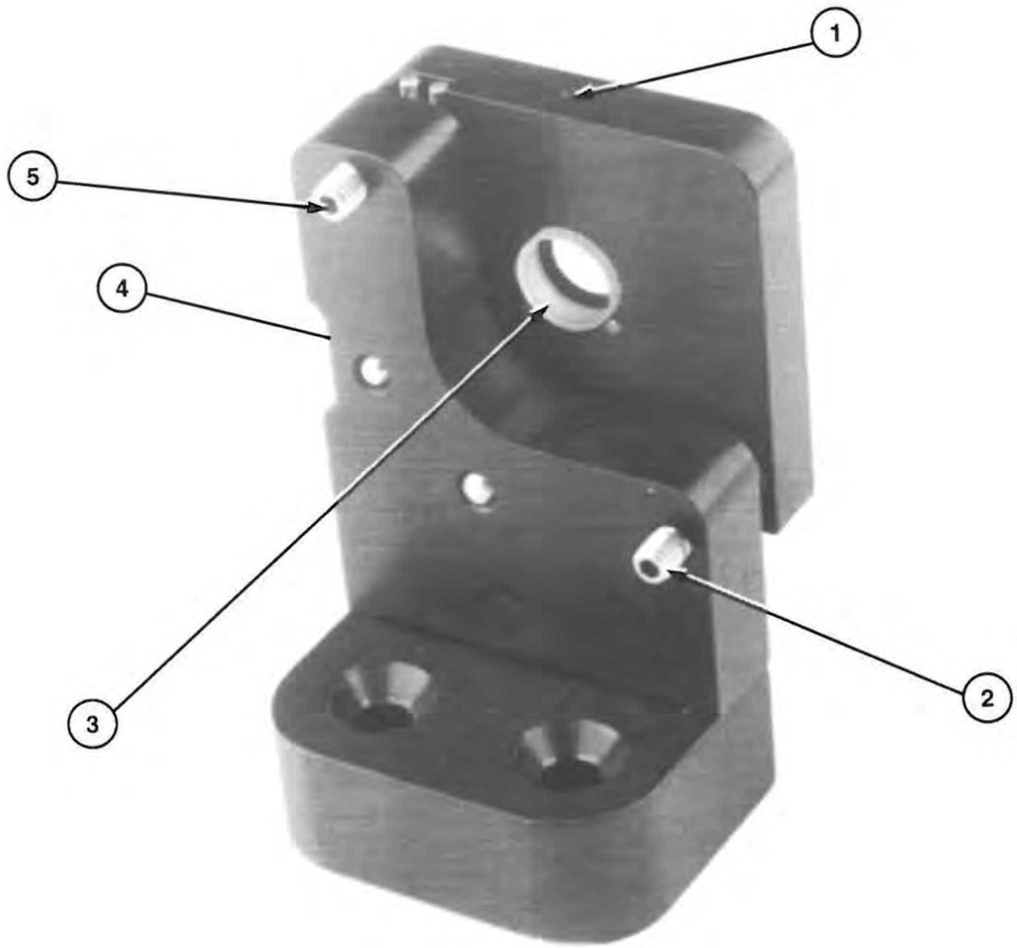


1. GTI vertical tilt angle control
2. GTI horizontal tilt angle control
3. GTI assembly setscrew
4. GTI tensioning screws (not visible, refer to Figure 3-3)
5. Photocell connector
6. PZT drive connector
7. GTI assembly

Figure 3-18. Gires-Tournois Interferometer (GTI) Controls

Table 3-18. Gires-Tournois Interferometer (GTI) Controls

CONTROL	FUNCTION
GTI horizontal and vertical tilt angle controls	Allows horizontal and vertical adjustment of the GTI during alignment.
GTI tensioning screws	Determines the amount of pressure required to adjust GTI vertical and horizontal tilt angle controls. The adjustment is performed at the factory and no further adjustments are necessary.
GTI assembly setscrew	Secures the GTI assembly in the mount assembly. Used when changing GTIs (e.g., when changing optics sets).
GTI assembly	The GTI automatically adjusts the group velocity dispersion to the correct level as the laser is tuned using a detection and feedback loop.



1. M9 optic setscrew
2. M9 horizontal tilt angle adjustment
3. M9 optic (coated surface shown)
4. M9 tensioning screw (not visible)
5. M9 vertical tilt angle adjustment

Figure 3-19. M9 Controls

Table 3-19. M9 Controls

CONTROL	FUNCTION
M9 optic	Flat mirror in the cavity.
M9 horizontal and vertical tilt angle adjustment	Allows horizontal and vertical adjustment of the fluorescent spot onto M8 (or beam) during CW cavity alignment.
M9 optic setscrew	Secures M9 optic in the optic mount assembly.
M9 tensioning screw	Determines the amount of pressure required to adjust M9 vertical and horizontal tilt angle controls. This adjustment is performed at the factory and no further adjustments are necessary.

Operator's Manual

Chapter Four
Daily Operation

COHERENT

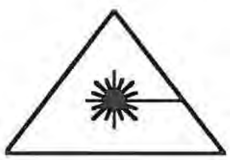
INTRODUCTION

This chapter contains procedures for daily turnon after temporary or long term shutdown.

The procedures contained in this chapter assume the user is familiar with the ion pump laser. Refer to the ion pump laser operator's manual as necessary to perform steps in the following procedures such as ion pump laser startup, alignment, output beam optimization, use of the remote control module, and location of components and alignment/adjustment controls.

It is assumed the ion pump laser produces a vertically polarized 8.0 Watt (low power) or 12 to 14 Watt (high power) multiline visible pump beam and that PowerTrack is turned on.

DAILY TURNON



Wear laser safety glasses to protect against the radiation generated from the Mira and the pump laser. Refer to the fact sheets for the specific wavelengths being generated. Refer to the pump laser manual for safety precautions and wavelengths generated from the pump laser. It is assumed that the operator has read Chapter One, Safety, and is familiar with laser safety practices and the dangers involved.

Both the Mira laser and the pump laser are designed to be operated with the covers in place. Operation of the laser with the protective housing removed will allow access to hazardous visible and invisible radiation. The laser housings should only be opened for the purposes of maintenance and service by trained personnel cognizant of the hazards involved.

Extreme caution must be observed in operating the laser with the cover removed. There are high-power reflections which may exit at unpredictable angles from the laser head. These beams have sufficient energy density to cause permanent eye damage or blindness.

Perform daily turnon in accordance with Figure 4-1.

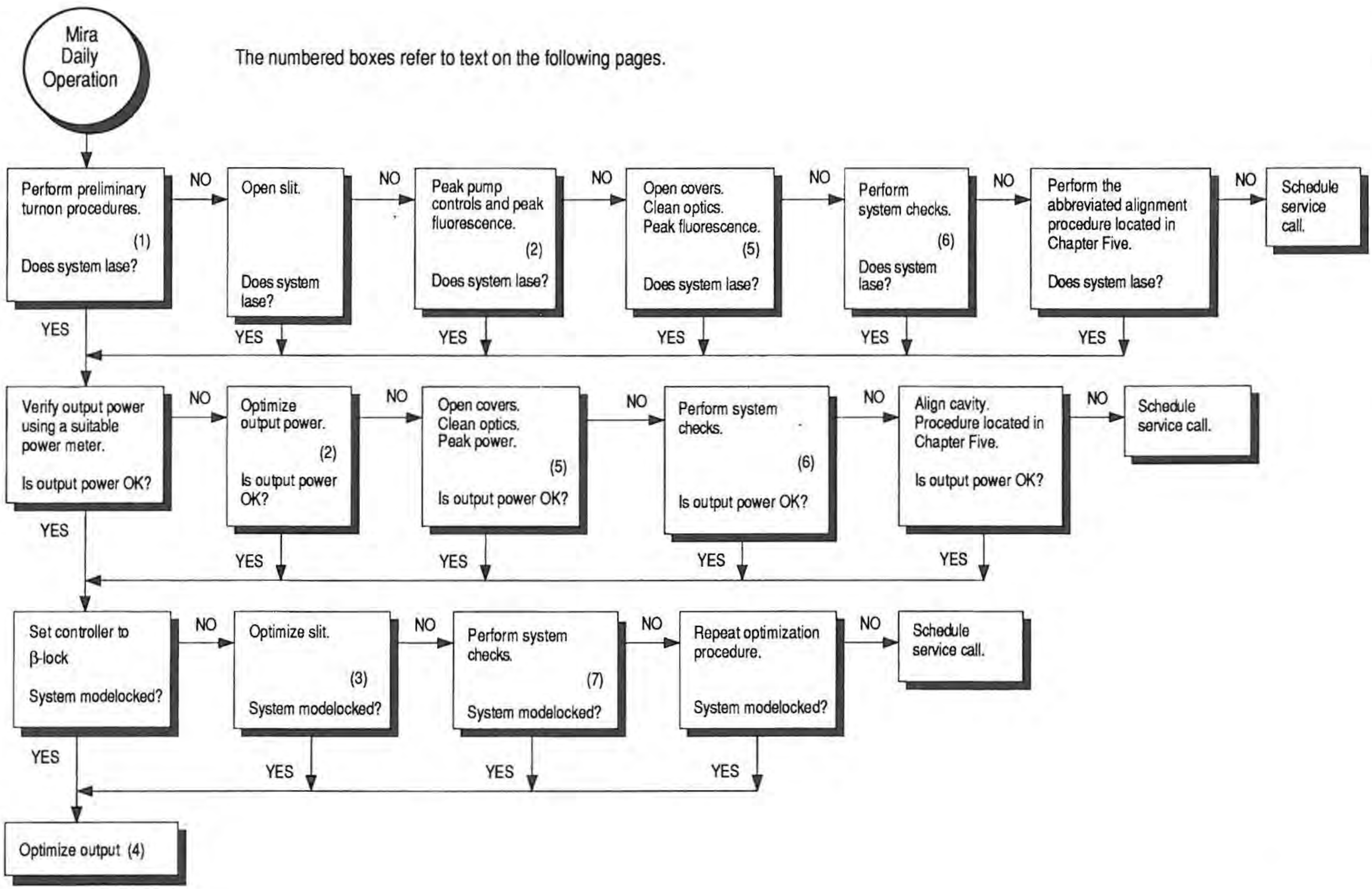


Figure 4-1. Mira Daily Operation

The numbered paragraphs below are keyed to, and supplement the flow chart on Figure 4-1.

[1] The following procedures are intended for use when the system has been completely shutdown, such as overnight. Use the short term turnon procedures if the system has been temporarily shut down.

Avoid cooling water flow to the titanium:sapphire crystal for long periods when the pump beam is not striking the crystal. Failure to observe this could result in the formation of condensation which could contaminate the crystal.

Avoid operating the Mira laser with the pump beam traveling through the crystal without cooling water turned on. Failure to observe this could result in damage to the crystal.

In summary, in order to avoid crystal damage, turn on the cooling water when the pump beam is striking the crystal and turn off the cooling water when the pump beam is not striking the crystal.

1. Turn on the cooling water for the titanium:sapphire crystal and ion laser.
2. Turn on the nitrogen (N_2) to purge the Mira cavity. It is recommended that the cavity is purged with dry N_2 when operating above 870 nm. Between 920 and 970 nm, a high velocity purge for several hours to reduce the cavity humidity to near zero may be required. Also, a dry N_2 purge may be required when operating at 761 ±5 nm and at 820 ±5 nm.
3. Turn on the ion laser in accordance with the ion laser operator's manual. Ensure PowerTrack™ is turned on. Allow the pump beam to strike the titanium:sapphire crystal so that condensation will not form.
4. After the appropriate warm-up period, optimize the ion laser output power and ensure it is at the proper operating level.
5. If the Mira controller is turned off, turn on the controller and set the CW/ML/β-Lock select switch to CW. Toggle the AUTO RANGE/PEAK RESET switch to the PEAK RESET position.

   If the Mira controller is turned on, ensure the CW/ML/β-LOCK select switch is set to CW. Toggle the AUTO RANGE/PEAK RESET switch to the PEAK RESET position.

[2] Optimize output power (or fluorescence) by adjusting the following controls in the order listed.

- Pump P2 controls.
- GTI vertical and horizontal tilt angle controls.
- Verify the BRF micrometer is set to the peak of the gain curve (or desired wavelength) in accordance with the tuning chart (wavelength vs micrometer setting) furnished with the system.

It is recommended that the cavity is purged with dry N_2 when operating above 870 nm. Between 920 and 970 nm, a high velocity purge for several hours to reduce the cavity humidity to near zero may be required. Also, a dry N_2 purge may be required when operating at 761 ±5 nm and at 820 ±5 nm.

The numbered paragraphs below are keyed to, and supplement the flow chart on Figure 4-1.

[3] Optimize the slit width as follows:

1. Open the slit by turning the slit width control clockwise until the output power is maximized.
2. Maximize output power by adjusting the following controls in the order listed.
   - P2 pump controls.
   - GTI vertical and horizontal tilt angle controls.
   - Verify the BRF micrometer is set to the peak of the gain curve (or desired wavelength) in accordance with the tuning chart (wavelength vs micrometer setting) furnished with the system.
3. Reduce the slit width by turning the slit width control counterclockwise until the output power is reduced approximately 50%.
4. Center the slit on the beam by adjusting the slit translation control for maximum output power.
5. Repeat steps 3 and 4 to ensure slit is centered on the beam.
6. Open the slit by turning the slit width control clockwise until the output power is maximized.
7. Set the controller CW/ML/β-Lock select switch to β-LOCK.
8. Reduce the slit width by turning the slit width control counterclockwise to obtain maximum average power with zero CW content as viewed on the controller display.
9. Connect the fast diode output from the input bezel of the Mira to an oscilloscope. The fast diode output should be 50Ω terminated for high bandwidth response.
10. Set the oscilloscope to 10 mv per division and a time base of 20 ns. Trigger off the fast diode input. The signal on the oscilloscope should look like Figure 4-2.
11. Slowly adjust the slit width until the the display on the oscilloscope looks like Figure 4-3. Pulse spacing should be approximately 13 ns as shown. Also refer to Chapter 7, "Slit Width".
12. Reduce sweep speed to 0.1 microseconds. If the display on the oscilloscope looks like Figure 4-4, the slit is too narrow. Open slit until pulse train shows no low frequency modulation, and CW component display on controller shows no CW.

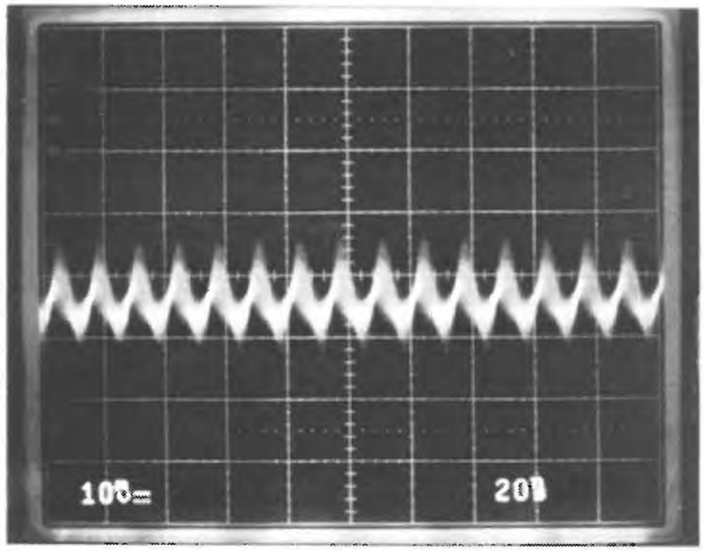


Figure 4-2. CW Signal Slit Open

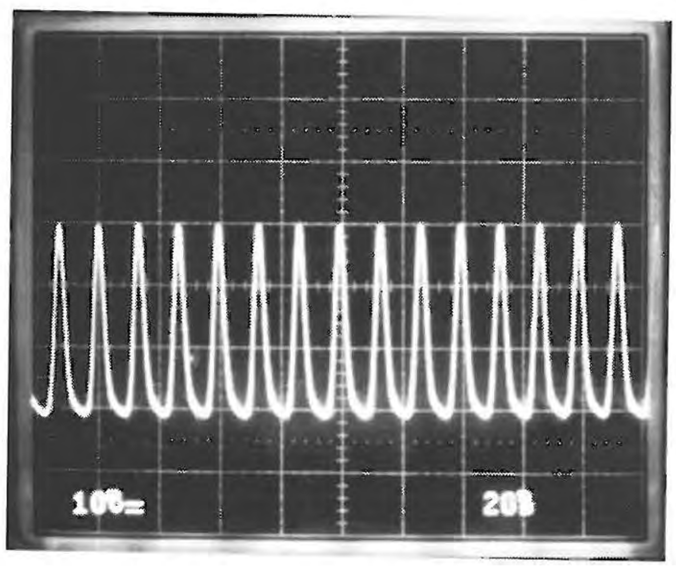
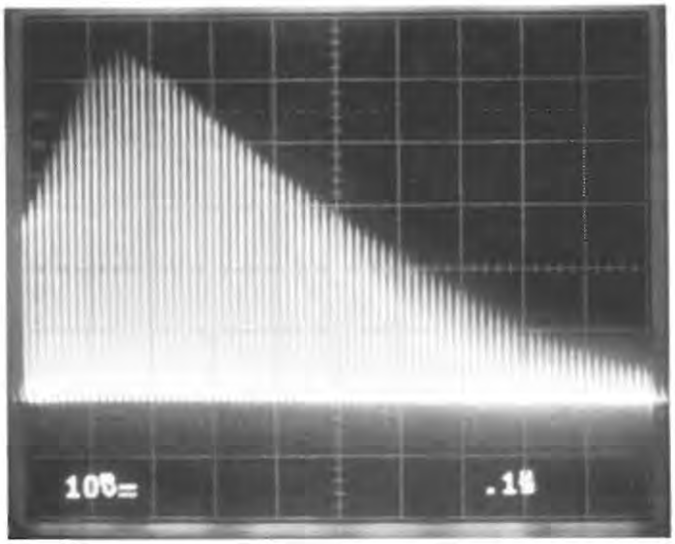
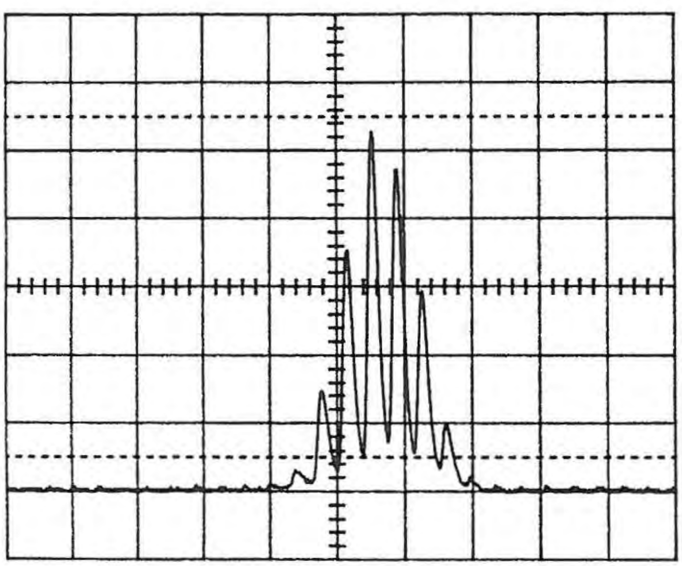


Figure 4-3. Modelocked Signal Slit Optimized



a. Oscilloscope Display



b. Autocorrelator Display

Figure 4-4. Modulation of Pulse Envelope—Slit Too Narrow

The numbered paragraphs below are keyed to, and supplement the flow chart on Figure 4-1.

[4] Optimize the output as follows:

1. Connect the fast diode output from the input bezel of the Mira to an oscilloscope. The fast diode output should be 50Ω terminated for high bandwidth response.
2. Set the oscilloscope to 10 mv per division and a time base of 20 ns. Trigger off the fast diode input. The signal on the oscilloscope should look like Figure 4-2 or 4-3.
3. Verify that the display on the oscilloscope looks like Figure 4-3.
4. If necessary, slowly adjust the slit width until the the display on the oscilloscope looks like Figure 4-3.
5. Set sweep speed to 0.1 microseconds. If the display on the oscilloscope looks like Figure 4-4, the slit is too narrow. Open slit until pulse envelope shows no modulation.
6. Once the system is modelocked, make small adjustments to the bias to optimize pulse width.

[5] Clean optics and optimize power as follows:

1. Clean all optics in accordance with the procedures in Chapter Six.
2. Optimize power (or fluorescence) using the following controls:
   - Pump P2 horizontal and vertical tilt angle controls.
   - GTI vertical and horizontal tilt angle controls.

[6] Perform the following system checks:

1. Ensure cooling water to the crystal is turned on and the flow rate pressure and temperature are correct.
2. Verify the output power from the pump laser is correct.
3. Verify the pump laser PowerTrack is turned on.
4. Verify the output mode structure of the pump laser is correct.
5. Verify the BRF micrometer is set to the peak of the gain curve in accordance with the tuning chart (wavelength vs micrometer setting) furnished with the system.

The numbered paragraphs below are keyed to, and supplement the flow chart on Figure 4-1.

[7] Perform the following system checks:

1. Verify that the cables going to the GTI are connected.
2. If operating at 761 ±5 nm, 820 ±5 nm, or above 870 nm, verify that the cavity has been purged. In particular, if operating between 920 nm and 970 nm, the system should be purged for several hours with high volume dry nitrogen, and remain sealed.
3. For ease of operation, in case of difficulty, verify that the BRF micrometer is set to the peak of the gain curve in accordance with the tuning chart (wavelength vs micrometer setting) furnished with the system.
4. Verify that the starter galvo is operational. The starter butterfly should oscillate when the controller CW/ML/β-Lock select switch is set to ML and the slit is opened.
5. Ensure cooling water to the crystal is turned and the flow rate pressure and temperature are correct.
6. Verify that the output power from the pump laser is correct.
7. Verify that the pump laser PowerTrack is turned on.
8. Verify that the output mode structure of the pump laser is correct.
9. Check the system for modelocking as follows:
   - Connect the fast diode output from the input bezel of the Mira to an oscilloscope. The fast diode output must go through a 50 ohm load before going into the oscilloscope.
   - Set the oscilloscope to 10 mv per division and a time base of 20 ns. Trigger off the fast diode input. The signal on the oscilloscope may look like Figure 4-2.
   - Verify that the display on the oscilloscope looks like Figure 4-3. Pulse spacing should be approximately 13 ns as shown. Also refer to Chapter 7, "Slit Width".
   - If necessary, slowly adjust the slit width until the the display on the oscilloscope looks like Figure 4-3.
   - Set sweep speed to 0.1 microseconds. If the display on the oscilloscope looks like Figure 4-4, the slit is too narrow. Open slit until pulse train shows no low frequency modulation

LONG TERM SHUTDOWN

Long term shutdown involves turning off all equipment and is intended for extended periods of time such as overnight. Use the temporary shutdown procedures for shorter periods of time when complete shutdown is unnecessary.

1. Block the ion laser pump beam.
2. Turn off the ion laser in accordance with the ion laser operator's manual.
3. Turn off the cooling water flow to the titanium:sapphire crystal.
4. Turn off the nitrogen to the Mira or reduce flow to low rate.
5. Set the CW/ML/β-Lock select switch on the Mira controller to CW (or turn off the Mira controller).

SHORT TERM SHUTDOWN

The following procedure is intended for short term use such as several hours. All equipment is left turned on. Use the long term shutdown procedures for longer periods of time (over 8 hours).

1. Block the ion laser pump beam.
2. Turn off water to titanium:sapphire crystal (eliminates condensation).
3. Set the CW/ML/β-Lock select switch on the Mira controller to CW (or turn off the Mira controller).

SHORT TERM STARTUP

1. Turn on water to titanium:sapphire crystal.
2. Open the ion laser shutter.
3. Turn on the Mira controller. Set the CW/ML/β-Lock select switch on the Mira controller to β-Lock. If any problems are encountered during startup, perform turnon in accordance with Figure 4-1.

USING POWER DISPLAY TO ACHIEVE LASER ALIGNMENT

The internal power meter and display have been designed to allow quick alignment of laser cavity. If any mirror is sufficiently misaligned, the system will not lase. However, the fluorescence caused by the pump is detectable and when the mirrors are close to being aligned, this fluorescence is enhanced. Therefore, adjusting mirrors to increase the fluorescence level will eventually bring them into alignment sufficiently to allow lasing action. The fluorescence level is many orders of magnitude lower than the lasing level and hence the power meter must have many orders of magnitude of dynamic range in order to correctly measure both lasing levels and fluorescence.

A special feature of this meter is that it will automatically change ranges as the power is increased. However, it will not autorange downward. This prevents annoying range changes when the power is erratic as it is when the mirrors are

close to alignment. In order to autorange downward, in the event that the power decreases and cannot be recovered easily, the AUTO RANGE switch should be momentarily actuated.

Each time the power has increased sufficiently to require a range switch, an audible beeper will sound. Therefore, every time a beep is heard, a new high power has been achieved, higher than the previous one, indicating a steady progression of mirror adjustments toward ultimate alignment.

In between beeps, the power bar display and vernier continually increase in length as each new range is reached.

Before lasing action occurs, it is necessary to detect very small increases in the fluorescence level in order to determine the correct adjustment direction. To this end, the sensitivity of the display can be enhanced by introducing negative offset followed by a gain increase. Most of the steady signal is suppressed, leaving only variations visible. This feature is referred to as DC Suppress.

The DC Suppression feature is automatically activated by the system computer at appropriate intensity levels. The word DC SUP will appear in the lower left corner of the display when this feature has been activated.

In summary, if lasing action is lost, the following sequence of actions set up the meter for laser alignment

1. Depress AUTO RANGE momentarily
2. The word DC SUP should appear on the display

The power display is now set to its maximum sensitivity for alignment.

Other Features of the Display

1. Peak marker

   The peak marker remembers the peak power reached since the last peak reset. It will remember the last peak even if the meter autoranges down in intensity momentarily.

   PEAK RESET

   As the name suggests, this control resets the peak marker to the present power. It also resets the vernier to zero.

   Vernier

   This display magnifies any changes in power from a a reference level established at the most recent Peak Reset. It is very useful for monitoring

power increases or decreases from a reference level while adjusting alignment, slit width etc. It is reset to zero when a peak reset is requested.

2. Digital power indicator

   This number has up to four digits displayed and is proportional to average power out for a fixed wavelength. It can be used as a logging device to record and compare powers. If an absolute power is required it is suggested that a calibrated thermal power meter such as the Coherent 210 be used.

   When in the DC SUP mode, (system is not lasing) this number is replaced by the word FLUOR until the intensity reaches a high enough level.

3. RH

   Indicates the relative humidity in the laser head at the position of the head board.

4. Bias

   This number indicates the optimum lock point on the GTI fringe.

5. PZT

   This number indicates the voltage that is being applied to the GTI.

Error Messages

Power display error messages are shown in Table 4-1.

Table 4-1. Power Display Error Messages (1 of 2)

Error Message / Meaning	Action Required
Power Low-return switch to CW The control box was turned on with the switch in CW. The position of the switch was subsequently changed and the laser was not lasing. *(Will be displayed until switch is returned to the CW position)*	Return controller to the CW position and re-establish lasing.
Power low-use CW mode The laser is not lasing and the switch position is in the ML or β-Lock position. The computer cannot determine the system configuration. *(Will be displayed until switch is returned to the CW position)*	Return controller to the CW position and re-establish lasing.
DC Suppressing Out of Range This indicates a failure of the fluorescence power meter, Most likely due to component malfunction in the controller or head board. The processor has tried all possible gain settings and the DC Suppression DAC values before issuing this message. The fluorescence power meter information will be invalid but other functions may be intact. *(Will be displayed for 1 second, then operation continues)*	Check the following: • Head board alignment • Check all connections
Stage 1 Saturation Error The output of the first stage amplifier of the power meter exceeds 1.6V at the minimum possible gain setting. The power meter information will be invalid but other system functions may be intact. *(Will be displayed for 1 second, then operation continues)*	Check the following: • Check alignment of the head board • Attenuate the beam entering the photocell
Low Power The laser power has decreased by more than half during Beta lock operation. *(Will be displayed as long as symptom persists)*	Check the following: • Ion laser pump power meeting specification • Adjust the P2/P3 tilt angle controls • Adjust Mira GTI vertical/horizontal tilt angle controls
Error: GTI signal too low The light level on the GTI photocell is insufficient. *(Will be displayed as long as symptom persists)*	Check the following: • Ion laser output power meeting specification • Mira output power meeting specification • Check alignment of the GTI

Table 4-1. Power Display Error Messages (2 of 2)

Error Message / Meaning	Action Required
Error: GTI signal too high The GTI photocell is saturated at the minimum gain of the amplifier. *(Will be displayed as long as symptom persists)*	Check the following: • Ion laser output power meeting specification • Mira output power meeting specification • Check alignment of the GTI • Verify GTI matches wavelength used by referring to fact sheets in Appendix A.
Error: GTI optimization failed The signal on the GTI photocell is changing too rapidly. *(Will be displayed as long as symptom persists)*	Check the following: • Mira output power meeting specification • Check alignment of the GTI
Error: Power signal too low The signal on the external power meter detector used by β-Lock is too low for the servo controlled operation. *(Will be displayed as long as symptom persists)*	Check the following: • Ion laser output power meeting specification • Mira output power meeting specification • Head board alignment
Error: Power signal too high The signal on the external power meter detector used by β-Lock mode is too high for Servo controlled operation. *(Will be displayed as long as symptom persists)*	Check the following: • Ion laser output power meeting specification • Mira output power meeting specification • Head board alignment • Power meter photocell must be attenuated
Error: Power gain optimization failed The power meter signal is changing too rapidly. *(Will be displayed as long as symptom persists)*	Check the following: • Ion laser output power meeting specification • Mira output power meeting specification • Verify BRF is on correct tuning order • Optimize slit
Error: PZT at limit The PZT on the GTI is constantly being driven to the extremes of its range. *(Will be displayed as long as symptom persists)*	Check the following: • Check connectors at the GTI and base plate • Verify GTI alignment • Verify BRF is on correct tuning order • Optimize slit

Operator's Manual

Chapter Five
Installation and Alignment

Coherent

INTRODUCTION

Installation and alignment procedures contained in this chapter are intended for use during initial installation or if the pump laser or Mira laser head has been moved. Re-alignment after an optics/wavelength change is contained in the applicable chapter. Refer to Chapter Three as required for the location of all controls used in this chapter.

The recommended pump laser for the Mira is the Innova 200, 300, or 400 ion laser with PowerTrack™. The pump laser must meet all specifications before starting Mira alignment. Refer to the pump laser operator's manual as required for pump laser operation, alignment, turnon and shutdown, and safety information.

COOLING WATER

The Mira titanium:sapphire crystal requires a flow of cooling water for proper operation. Best performance will be achieved using a separate closed loop water conditioner that maintains the water temperature to the crystal within ±1°C. Other water parameters are listed below.

Minimum Flow Rate	.08 gal/min
Maximum Pressure	30 psi
Maximum Temperature	25°C

DRY NITROGEN PURGE

In order for the Mira to modelock properly at certain wavelengths, the cavity must be purged with dry nitrogen. It is recommended that for operation above 870 nm, dry nitrogen purge be maintained. In particular, between 920 and 970 nm, strong water absorption interferes with the operation of the system. A high velocity purge will be needed for several hours to reduce the humidity below 5%. Other absorption lines to be aware of are in the vicinity of 760 and 820 nm. Recommended flow rates are listed below.

Initial Purge	10 CFH
Later purges	2 CFH.

EQUIPMENT USED DURING INSTALLATION AND ALIGNMENT

- Power meter, Coherent Model 210 or equivalent (0 to 10 W).
- Laser safety glasses to protect against the wavelength exiting the laser head and to protect against the pump beam wavelength. Refer to the fact sheets in Appendix A for specific wavelengths.

- IR viewer.
- Accessory kit.

Installation and Alignment Summary

A summary of Mira installation is listed below. The following paragraphs in this chapter contain detailed procedures for each item listed.

- Install the ion pump laser in accordance with the pump laser operator's manual.
- Adjust the pump laser output beam height and level the beam with respect to the optical table using alignment apertures provided.
- Evaluate the pump laser output beam quality.
- Install the Mira using the abbreviated alignment procedure.
  - √ Position the Mira so that the pump beam enters the cavity as described in the abbreviated alignment procedure.
  - √ Adjust the Mira to obtain lasing .
  - √ Modelock the laser.
  - √ Optimize the output parameters.
- If lasing cannot be achieved using the abbreviated alignment procedure (after verifying that the procedure was performed correctly), perform the Full Alignment Procedure located later in this chapter.

  The abbreviated alignment procedure is appropriate when the laser was operating properly when previously shut down and that this cavity mirror alignment is still intact. If no mirrors have been removed or adjustment knobs altered, the abbreviated alignment is usually all that will be required, even after shipment. The full alignment procedure is appropriate when the previous cavity mirror alignment has been lost and thus the adjustment (or verification) of each cavity mirror is necessary.

  The abbreviated alignment procedure can also be used if the *pump* laser has been moved or replaced. In this case, the pump laser is repositioned to satisfy initial alignment criteria rather that repositioning the Mira. The criteria is that the pump beam at low power is simultaneously centered on:

  - √ Pump optic P0 (for straight in pumping) or P1 (for left side or right side pumping)
  - √ Lens L1
  - √ Folding optic M10
  - √ Titanium:sapphire crystal

ABBREVIATED ALIGNMENT PROCEDURE

It is recommended that safety glasses are used when performing this alignment as stray beams could be present.

This procedure is intended for use during initial installation or if the Mira or pump laser (or both) have been moved. If proper operating results are not obtained, perform the Full Alignment Procedure located in this chapter.

INSTALLATION NOTES

- The pump laser should be equipped with PowerTrack. PowerTrack should be turned on and the pump laser should also be operated in Light Regulation Mode (see pump laser operator's manual for...)
- The pump laser can be installed for left side, right side, or straight in pumping.
- The pump laser output beam must be multiline visible.
- Correct results may not be obtained if the pump laser is other than a Coherent Innova 200, 300, or 400 ion laser.
- If dirt or other foreign material on an optic is noticed during the installation and alignment procedure, clean the optic in accordance with the cleaning procedures located in Chapter Six.

For maximum stability, it is recommended that the use of table mounted beam steering mirrors or exceptionally long distances between the ion and Mira laser be avoided. This could result in pump beam power loss, thermal angular instability, mode degradation and altered beam divergence which will impair performance. It is also recommended that user provided beam tubes be installed between the pump laser and Mira laser for safety and stability. Exposed high power beam paths can be a laser safety hazard and air currents can have a significant beam steering effect.

Configuring the Mira for Left Side, Right Side, or Straight In Pumping

The pump laser can be installed for left side, right side, or straight in pumping (Figure 5-1). If the pump optic P0 mount is to be installed at this stage or the pump optic P1 mount is moved to configure Mira for a different pump configuration, perform the Coarse Pump Alignment procedures below. Final adjustment for P1 is located in the Mira Installation procedure located later in this chapter.

Coarse Pump Alignment Procedure

Straight In Pumping

For straight in pumping, the P0 pump optic assembly is installed in the location shown on Figure 5-2. Pump optic P1 and the P1 mount screw must also be located in the position shown on Figure 5-2. If the Mira is received configured for straight in pumping and the laser will be used in that configuration, do not adjust P0 or P1. Proceed to the procedure for pump laser setup.

If the P0 mount requires installation, perform the following installation procedures.

1. Block the ion laser pump beam.
2. Place the P0 mount on the baseplate and loosely install only the one mount retaining screw indicated in Figure 5-2.
3. Position the P0 mount so that the optic face is perpendicular to the incoming beam.
4. Ensure the pump laser is at low power (must be less than 100 mW). Open the pump laser shutter.
5. Adjust the P0 vertical tilt angle control so that the pump beam retro-reflection is at the same vertical height as the incoming beam.

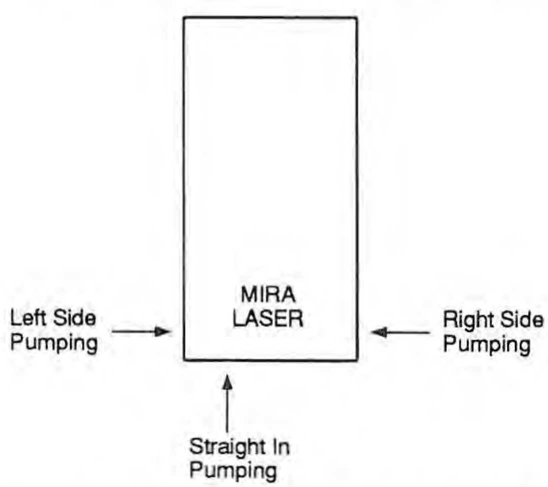


Figure 5-1. Directions for Straight-In, Left-Side and Right-Side Pumping

6. Block the ion laser pump beam. Rotate the P0 mount and install the second mounting screw. Tighten both P0 retaining mounting screws.

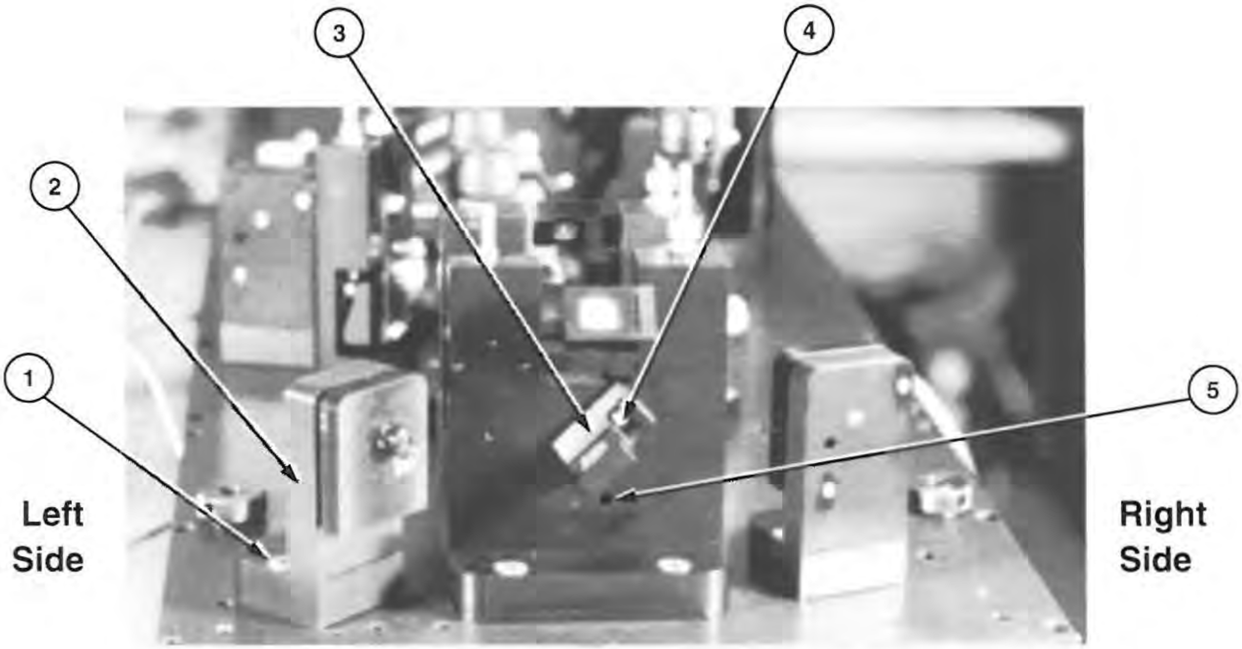
7. Adjust the P0 horizontal tilt angle control to horizontally center the pump beam on P1. P1 may require repositioning as described below before this step can be completed. Readjustment of the vertical control should not be necessary at this time.

If the mounting screw for pump optic assembly P1 must be moved to achieve straight in pumping (i.e., if the laser was previously configured for right-side pumping), perform the following procedure to roughly align the P1 mount. Final P1 adjustment instructions are located in the Mira installation procedures.

1. Block the ion laser pump beam.

2. Remove the retaining screw from the right side position indicated by arrow 5 on Figure 5-2.

3. Position the P1 optic assembly at approximately 45 degrees with respect to horizontal and reinstall the retaining screw in the left side position indicated by arrow 4 on Figure 5-2.



1. P0 mount retaining screws
2. P0 optic assembly
3. P1 assembly
4. P1 mount retaining screw for left-side (and straight-in) pumping
5. P1 mount hole for right side pumping

Figure 5-2. Mira Pump Configurations

Right Side Pumping

For right side pumping, the P0 pump optic assembly is not used and it does not matter whether it is installed or not. The P1 mount retaining screw must be in the position indicated by arrow 5 on Figure 5-2. If the Mira is received configured for right side pumping and the laser will be used in that configuration, do not adjust P0 or P1. Proceed to the procedure for pump laser setup.

If the mounting screw for pump optic assembly P1 must be moved to achieve right side pumping, perform the following procedure to roughly align the P1 mount. Final P1 adjustments are located in the Mira installation procedures.

1. Block the ion laser pump beam.
2. Remove the retaining screw from the position indicated by the arrow 4 on Figure 5-2.
3. Position the P1 optic assembly at approximately 45 degrees with respect to horizontal and reinstall the retaining screw in the position indicated by arrow 5 on Figure 5-2.

Left Side Pumping

For left side pumping, the P0 pump optic assembly must be removed from the beam path if it is installed. The P1 mount retaining screw must be in the position indicated by arrow 4 on Figure 5-2. If the Mira is received configured for left side pumping and the laser will be used in that configuration, do not adjust P1. Proceed to the procedure for pump laser setup.

If the mounting screw for pump optic assembly P1 must be moved to achieve left side pumping, perform the following procedure to roughly align the P1 mount. Final P1 adjustment instructions are located in the Mira installation procedures later in this chapter.

1. Block the ion laser pump beam.
2. Remove the P0 pump optic assembly (if installed) by removing two retaining screws (Figure 5-2, item 1).
3. Remove the retaining screw from the position indicated by the arrow 5 on Figure 5-2.
4. Position the P1 optic assembly at approximately 45 degrees with respect to horizontal and reinstall the retaining screw in the position indicated by arrow 4 on Figure 5-2.

Pump Laser Setup

1. Ensure the pump laser is turned off.

2. Carefully lift the pump laser and install a retaining/positioning block (supplied with the Mira) under each foot. Ensure the correct blocks are used.

3. Position a power meter or beam block at the pump laser output aperture.

4. Turn on the pump laser in accordance with the pump laser operator's manual. Adjust output beam for low power output (approximately 100 mW). High and low power can be set in the pump laser's memory to accomplish toggling between the two power settings by pressing a single pushbutton.

Pump Beam Height and Leveling Adjustments

1. Position alignment fixture #1 (Figure 5-3) on the optical table approximately 6 inches (15 cm) in front the pump laser output aperture. Position the power meter or beam block behind the the alignment fixture.

2. Adjust the front legs of the pump laser so that the pump beam is centered in the top hole of alignment fixture aperture #1. Do this in accordance with the pump laser operator's manual. The pump laser should remain level (in the horizontal plane perpendicular to the beam axis) during this process.

3. Position alignment fixture #2 (Figure 5-3) approximately 4 feet (122 cm) in front the pump laser output aperture. Move the power meter or beam block behind the alignment fixture.

4. Adjust the rear feet of the pump laser so that the pump beam is centered in the top aperture of alignment fixture #2. The pump laser should remain level (in the horizontal plane perpendicular to the beam axis) during this process.

5. Repeat steps 1 through 4 until the output beam travels through the top apertures of both alignment fixtures without readjusting the pump laser. This positions the output beam parallel to the table top at 4.75 inches (12.06 cm) above the table. Leave the alignment fixtures in place.

6. Clamp down the ion laser head using the foot clamps provided in the Mira accessory kit. Verify that the beam did not move and still travels correctly through both alignment fixtures. If the beam moved, repeat the pump beam height and leveling adjustments procedure.

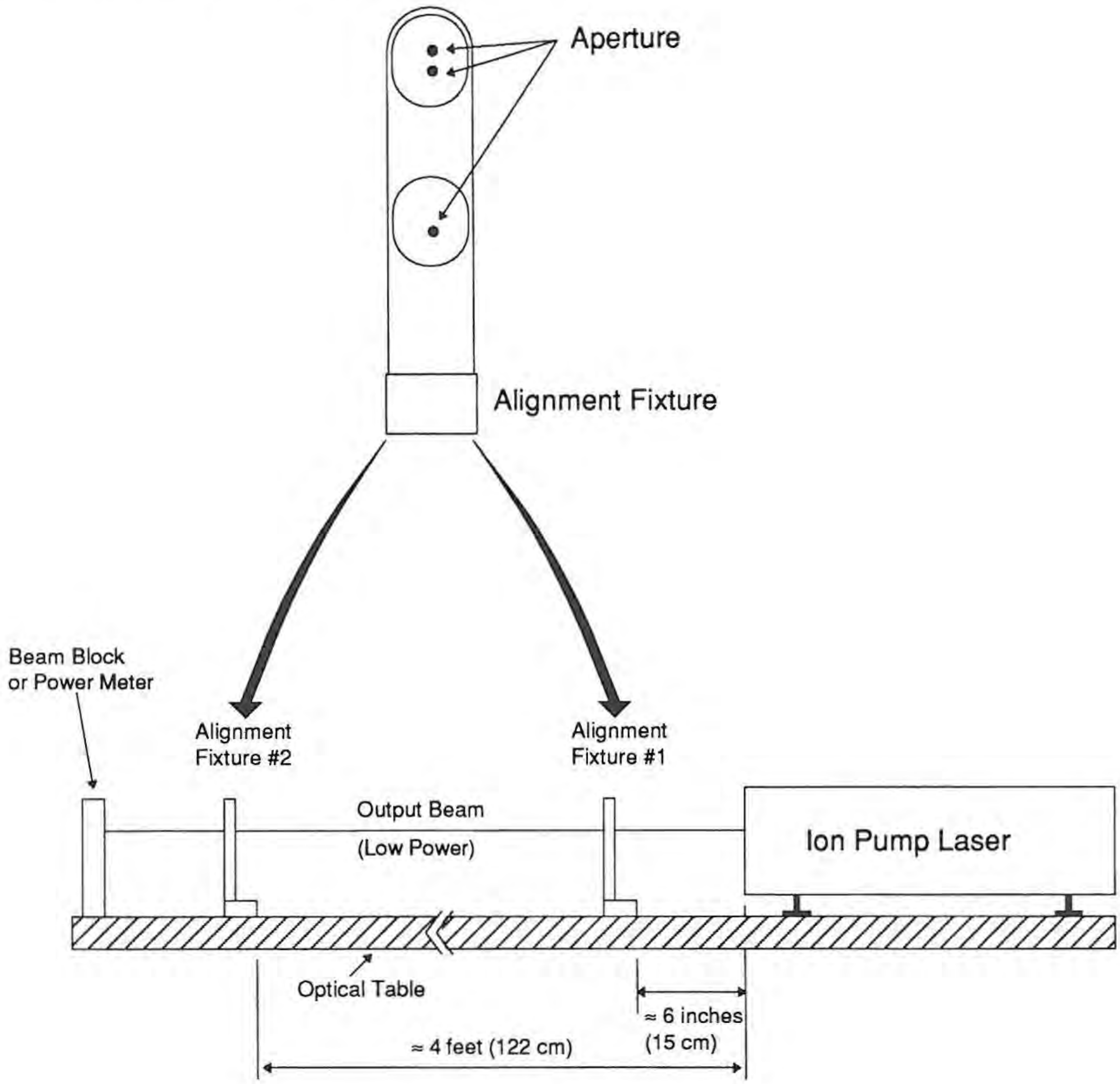


Figure 5-3. Pump Mirror Alignment

Mira Installation

1. Block the ion laser pump beam. Remove any power meter or alignment fixtures from the pump beam path. Open the Mira head covers. Position the Mira in the pump beam path approximately 6 inches (15 cm) from the pump laser allowing enough room for a power meter.

2. Ensure the pump laser is set to low power (less than 100 mW). Open the pump beam shutter. Position the Mira so that the ion beam enters the Mira and strikes the center of P0 (or strikes the center of P1 for left side or

right side pumping). The rear feet of the Mira are adjusted at the factory. Do not adjust the feet to center the pump beam on P0 (or P1).

3. If P1 mirror mount has not been moved (no pump configuration change), proceed to step 5.

   If P1 mirror mount has been moved, the factory alignment of P1 has been lost. Perform the following before proceeding to step 5.

   - Loosen the P1 mount retaining screw just enough so that P1 mount can be adjusted but will not move after release. Carefully adjust angle of P1 so that the beam strikes P4 in the center vertically. Be extremely careful that P1 is not so far out of nominal alignment that beam misses P2. This can cause a potential eye hazard.
   - Gently move Mira until beam is centered on P4 horizontally. Check that beam is also still striking center of P1. If this cannot be accomplished, make small adjustments to the P1 mount and to the position of Mira until this achieved. Do not tighten P1 retaining screw yet.

4. Locate the portion of the pump beam reflected from M5 to M8 and onward to M10. Rotate Mira on table and make small adjustments in P1 until pump beam is exactly centered on M10.

5. Verify the following:
   - The beam is still centered on P1 (and P4 if the P1 mirror mount was adjusted).
   - The beam is approximately centered on L1.

6. Gently slide back beam shields on the crystal and verify that the pump beam is travelling down the approximate center of the crystal, well clear of the edge of either face. The crystal can be damaged if the high power pump beam strikes the edge of the crystal. Return the beam tubes to the original position.

7. Secure the two rear Mira feet (input end) with the clamps provided.

8. Clamp the front foot.

9. Verify the following:
   - The beam is still centered on P1 (and P4 if the P1 mirror mount was adjusted).
   - The beam is approximately centered on L1.
   - The beam is striking the GTI window at the "2 o'clock" position (see Figure 5-4).
   - The beam is still centered on M10.

10. Connect the controller to the Mira laser head as shown in Figure 5-5 and turn on the controller.

11. Set the mode select switch to CW and toggle the AUTO RANGE/PEAK RESET switch to PEAK RESET.

12. Block the Mira output aperture with a power meter or beam block. Adjust the ion laser to normal operating level (high power).

13. Verify that the birefringent filter is at the peak of the tuning curve. Refer to the tuning chart for the micrometer setting.

14. Open the slit by rotating the slit width control (Figure 3-4) clockwise until it stops.

15. Hold the AUTO RANGE/PEAK RESET switch in the AUTO RANGE position for at least 2 seconds to activate the DC suppress function.

16. Make small adjustments to P2 vertical and horizontal tilt controls to maximize power on the controller display. If Mira lases, skip to step 19.

17. Make small adjustments to the following controls to maximize the power on the controller display. Adjust one control at a time and in the order listed.

    - GTI vertical and horizontal tilt angle controls.
    - P2 vertical and horizontal tilt angle controls.

    Repeat this step until Mira is lasing. Maximize power using the above controls after lasing starts.

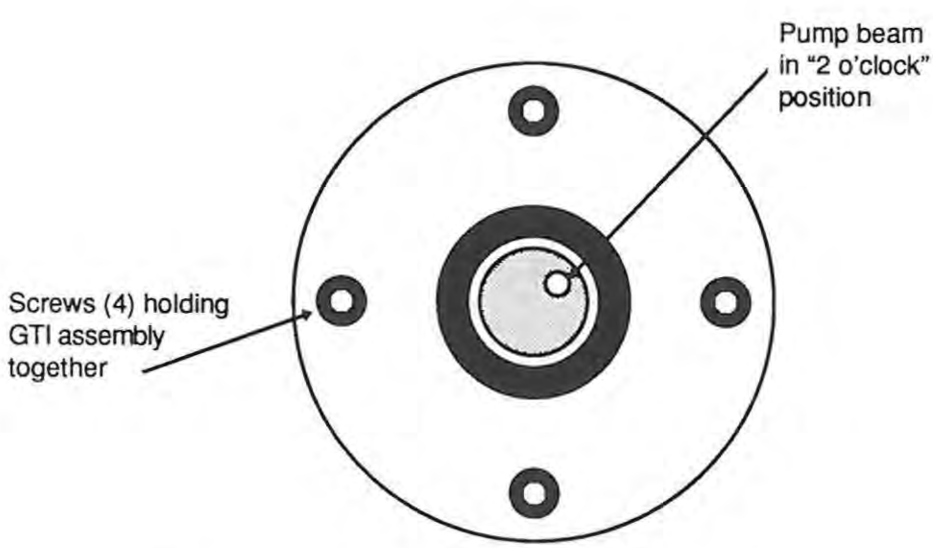
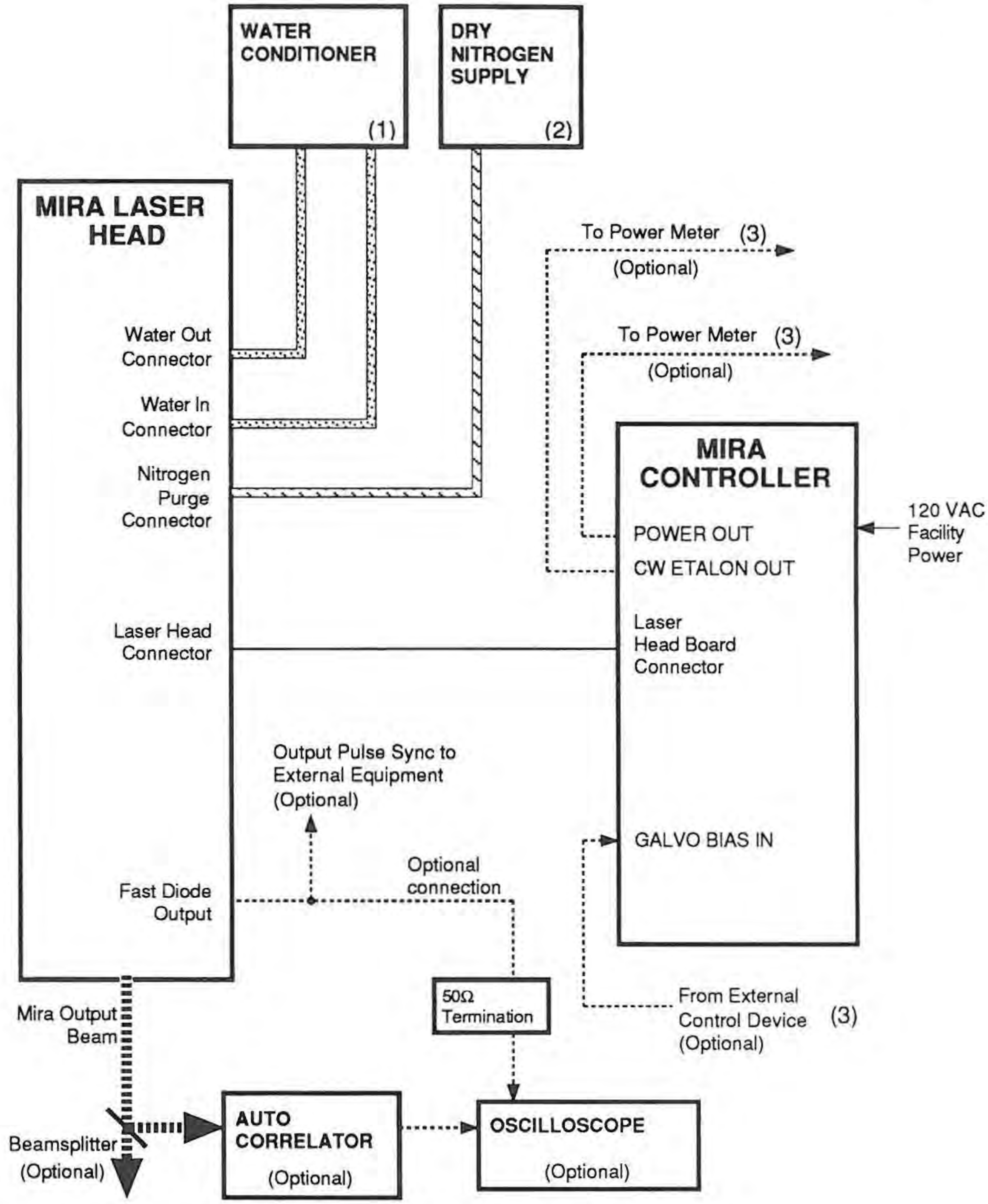


Figure 5-4. Pump Beam Spot on GTI Optic



(1) Refer to paragraph entitled "Cooling Water" in this chapter for specifications.

(2) If the system is tuned to operate at 765 ±5 nm, 825 ±5 nm, 880 to 900 or 930 to 970 nm, ensure that the N_2 purge is turned on.

(3) Refer to Table 3-12 for a description of the GALVO BIAS IN, POWER OUT, and the CW ETALON OUT signals.

Figure 5-5. Mira Interconnection Diagram

18. Once the cavity is lasing, maximize power (on controller display) by adjusting the following:
    - M5 vertical and horizontal tilt angle controls.
    - P2 vertical and horizontal tilt angle pump controls.
19. Hold the AUTO RANGE/PEAK RESET switch in the AUTO RANGE position for at least 2 seconds to activate the DC suppress function.
20. Use only the GTI vertical and horizontal tilt angle controls and the CW display to maximize power output.

Modelocking

1. After output power is maximized using the GTI, reduce the slit width (turn slit width control counterclockwise) until the output power is reduced approximately 50%.
2. Rotate the slit horizontal translation control for maximum output power. This centers the slit in the beam.
3. Repeat steps 1 and 2 to ensure slit is centered.
4. Set the CW/ML/β-Lock switch on the controller to the ML position. Optimize the BRF and slit width control for maximum power with zero CW content as viewed on the controller display.
    - The fast diode display from Mira laser head can be displayed on an oscilloscope to determine modelocked operation (Figure 4-3).
    - After system is modelocked, switch the controller to β-Lock position and adjust the bias level for optimum pulse width while observing the pulse on an oscilloscope via an autocorrelator.

FULL ALIGNMENT PROCEDURE

It is recommended that safety glasses are used when performing this alignment as stray beams could be present.

This procedure is intended for use when the abbreviated alignment procedure does not achieve the correct results, or when directed to do so elsewhere in this manual. Routine day to day operation of the Mira normally does not require that full alignment procedures are performed. If the Mira is not performing correctly, refer to Figure 4-1.

INSTALLATION NOTES

- The pump laser must be equipped with PowerTrack. PowerTrack must be turned on and the pump laser output beam must be stabilized.
- The pump laser can be installed for left side, right side, or straight in pumping. Refer to the paragraph titled "Configuring the Mira for Left Side, Right Side, or Straight In Pumping" to configure the Mira for different pump configurations.
- The ion pump laser output beam must be multiline visible.
- Correct results may not be obtainable if the pump laser is other than a Coherent Innova 200, 300, or 400 ion laser.
- If dirt or other foreign material on an optic is noticed during the installation and alignment procedure, clean the optics in accordance with the cleaning procedures located in Chapter Six.

It is recommended that beam steering mirrors for long distances between the ion and Mira laser not be used. Their use could result in pump beam power loss, mode degradation and altered beam divergence which will impair performance.

PUMP LASER SETUP

1. Ensure the pump laser is turned off.

2. Carefully lift the pump laser and install a positioning block (supplied with the Mira) under each foot. Ensure the correct blocks are used.

3. Position a power meter or beam block at the pump laser output aperture.

4. Turn on the pump laser in accordance with the pump laser operator's manual. Adjust output beam for low power output (approximately 100 mW). High and low power can be set in the pump laser's memory to accomplish toggling between the two power settings by pressing a single pushbutton.

Pump Beam Height and Leveling Adjustments

1. Position alignment fixture #1 (Figure 5-3) on the optical table approximately 6 inches (15 cm) in front the pump laser output aperture. Position the power meter or beam block behind the the alignment fixture.

2. Adjust the front legs of the pump laser so that the pump beam is centered in the top hole of alignment fixture aperture #1. Do this in accordance with the pump laser operator's manual. The pump laser should remain level (in the horizontal plane perpendicular to the beam axis) during this process.

3. Position alignment fixture #2 (Figure 5-3) approximately 4 feet (122 cm) in front the pump laser output aperture. Move the power meter or beam block behind the the alignment fixture.

4. Adjust the rear feet of the pump laser so that the pump beam is centered in the top aperture of alignment fixture #2. The pump laser should remain level (in the horizontal plane perpendicular to the beam axis) during this process.

5. Repeat steps 1 through 4 until the output beam travels through the top apertures of both alignment fixtures without readjusting the pump laser. This positions the output beam parallel to the table top at 4.75 inches (12.06 cm) above the table. Leave the alignment fixture in place.

6. Clamp down the ion laser head using the foot clamps provided in the Mira accessory kit. Verify that the beam did not move and still travels correctly through both alignment fixtures. If the beam moved, repeat the pump beam height and leveling adjustments procedure.

Mira Installation

1. Block the ion laser pump beam. Remove any power meter or alignment fixtures from the pump beam path. Open the Mira head covers. Position

the Mira in the pump beam path approximately 6 inches (15 cm) from the pump laser allowing enough room for a power meter.

2. Ensure the pump laser is set to low power (less than 100 mW). Turn on the cooling water to the Mira and open the pump beam shutter. Position the Mira so that the ion beam enters the Mira and strikes the center of P0. The rear feet of the Mira are adjusted at the factory. Do not adjust the feet to center the pump beam on P0.

3. If P1 mirror mount has not been moved (no pump configuration change), proceed to step 5.

   If P1 mirror mount has been moved, the factory alignment of P1 has been lost. Perform the following before proceeding to step 5.

   - Loosen the P1 mount retaining screw just enough so that P1 mount can be adjusted but will not move after release. Carefully adjust angle of P1 so that the beam strikes P4 in the center vertically. Be extremely careful that P1 is not so far out of nominal alignment that beam misses P2. This can cause a potential eye hazard.

4. Gently move Mira until beam is centered on P4 horizontally. Check that beam is also still striking center of P1. If this cannot be accomplished, make small adjustments to the P1 mount and to the position of Mira until this achieved.

5. Verify the following:

   The beam is still centered on P0 (straight in pumping), P1, and P4.

   The beam is approximately centered on L1.

6. Gently slide back beam shields on the crystal and verify that the pump beam is travelling down the approximate center of the crystal, well clear of the edge of either face. The crystal can be damaged if the high power pump beam strikes the edge of the crystal. Return the beam tubes to the original position.

7. Secure the two rear Mira feet (input end) with the clamps provided.

8. Clamp the front foot.

9. Verify the following:

   - The beam is still centered on P0 (straight in pumping), P1, and P4.
   - The beam is approximately centered on L1.
   - The beam is still centered on the crystal.

10. Connect the controller to the Mira laser head as shown in Figure 5-5 and turn on the controller.

11. Set the mode select switch to CW and toggle the AUTO RANGE/PEAK RESET switch to PEAK RESET.

12. Block the Mira output aperture with a power meter or beam block. Adjust the ion laser to normal operating level (high power).

13. Verify that the birefringent filter is at the peak of the tuning curve. Refer to the tuning chart for the micrometer setting.

14. Open the slit by rotating the slit width control (Figure 3-4) clockwise until it stops.

15. Hold the AUTO RANGE/PEAK RESET switch in the AUTO RANGE position for at least 2 seconds to activate the DC suppress function.

Cavity Alignment

1. Locate the pump beam reflection (in front of M8) from M5. Use M5 vertical and horizontal tilt angle controls to center the pump beam on M8 (Figure 5-6).

2. Locate the pump beam reflection (in front of M10) from M8. Use M8 vertical and horizontal tilt angle controls to center the pump beam on M10 (Figure 3-2).

3. Use M10 vertical and horizontal tilt angle controls to position the pump beam reflection on the front GTI optic at the "2 o'clock" position (Figure 5-4).

4. Locate the pump beam retro-reflection from the GTI as follows:
   - Adjust the ion pump laser to high power.
   - Use the GTI vertical and horizontal tilt angle controls to locate the retro-reflection on M10.
   - The correct retro-reflection is the brightest of the two reflections.
   - Adjust the GTI vertical and horizontal tilt angle controls to position the retro-reflection one beam diameter to the right of the pump beam on M10.

5. Close and center the apertures on M2 and M3. → reflective Starter ≈ ±10% ΔI when in fs-mode

6. Locate the outline of the butterfly projected on the M3 aperture. Use M4 vertical tilt angle controls to vertically position the fluorescence on the butterfly outline.

7. Use M4 horizontal tilt angle controls to horizontally position the fluorescence in the M3 alignment aperture. Open the M3 alignment aperture.

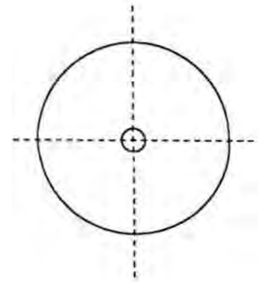


Figure 5-6. Pump Beam Spot on M8

8. Use M3 vertical and horizontal tilt angle controls to center the fluorescence on the M2 alignment aperture.

9. Remove slit assembly by loosening the two screws at base.

10. Use M2 vertical and horizontal tilt angle controls to position the fluorescence on to the center of the output coupler M1.

11. Verify that the birefringent filter is at the peak of the tuning curve. Refer to the test data sheet for micrometer setting.

12. Locate the retro-reflection from M1 on the M2 aperture. An IR viewer will make the spot easier to locate. Adjust M1 vertical and horizontal tilt angle controls until the retro-reflection is centered in the aperture. Open the M2 aperture.

13. Make small adjustments to the following controls to maximize the intensity on the controller display. Adjust one control at a time and in the order listed.

    - GTI vertical and horizontal tilt angle controls.
    - Output coupler M1 vertical and horizontal tilt angle controls.

    Repeat this step until Mira is lasing. Maximize power using GTI and output coupler M1 controls after lasing starts.

14. Once cavity is lasing, maximize output power by adjusting the following:

    - Output coupler M1 vertical and horizontal tilt angle controls.
    - M5 vertical and horizontal tilt angle controls (small adjustments).
    - P2 vertical and horizontal tilt angle controls.
    - GTI vertical and horizontal tilt angle controls.

15. Use an IR viewer to verify that the beam travels through the exact center of both butterfly arms vertically. If not, use M3 vertical tilt angle control

to adjust (walk) the vertical position on the butterfly arm closest to the slit. Use M4 vertical tilt angle control to adjust (walk) the vertical position on the butterfly arm closest to the side. Refer to the paragraph titled "Walking The Beam".

16. Use an IR viewer to verify beam travels through the center of output coupler. If not, walk the beam using M2 and M1.

17. Reinstall slit assembly.

18. Open slit fully.

19. Once the laser is optimized , reduce the slit width (turn slit width control counterclockwise) until the output power is reduced approximately 50%.

20. Rotate the slit horizontal translation control for maximum output power. This centers the slit in the beam.

21. Repeat steps 7 and 8 to ensure slit is centered.

22. Set the CW/ML/β-Lock switch on the controller to the ML position. Optimize the BRF and slit width control for maximum power with zero CW content as viewed on the controller display.
    - The fast diode display from Mira laser head can be displayed on an oscilloscope to determine modelocked operation (Figure 4-3).
    - After system is modelocked, switch the controller to β-Lock position and adjust the bias level for optimum pulse width while observing the pulse on an oscilloscope via an autocorrelator.

Walking the Beam

Walking the beam refers to the procedure to adjust the beam position between two adjacent mirrors such as M2 and M3. This is done while the system is lasing.

Assume that the beam is not striking M2 in the center. Walk the beam as follows:

1. Adjust the M3 vertical tilt angle control to move the beam in the direction to center the beam on M2 until the power has decreased approximately 20%.

2. Adjust M2 vertical and horizontal tilt angle controls to recover power.

3. Repeat steps 1 and 2 until the position on M2 is satisfactory. Each repetition of steps 1 and 2 moves the beam about 0.25 to 0.5 mm.

4. Performing steps 1 through 3 affects the beam position on all optics on the same side of the crystal. Continue to walk the beam on all optics progressing to the end mirror as listed below.

   - M4, M3, M2, M1
   - M5, M8, M10
   - M10, GTI

Operator's Manual

Chapter Six
Maintenance

COHERENT®

Introduction

This chapter contains procedures for cleaning optics, replacing damaged optics, and changing wavelength ranges.

If an optic is damaged, use the appropriate fact sheet in Appendix A to determine the part number, and use the optics replacement procedures in this chapter.

The Mira covers provide a tight seal. Operating the laser with the covers on and latched will reduce the need to clean optics.

Cleaning Optics

In order to maintain optimum performance from high-grade optics, proper cleaning is an absolute necessity. Laser optical components are routinely exposed to high energy levels. When optical coatings are clean, this energy will either be reflected or transmitted. Contaminants on the surface of the optic absorb energy, creating hot-spots which can burn the precision coating and dramatically reduce laser efficiency. Absorption caused by contaminated optical surfaces will degrade performance and shorten mirror life.

Contaminants which can cause absorption include a variety of particles which may fall on the optical surface or condense from surrounding vapors. Even lens tissue fibers, and plastic gloves can be a source of contaminants.

Cleaning Installed Optics

When possible, clean the optic while it is installed in the laser head to minimize disturbing the optical alignment.

1. Block the ion laser pump beam. Remove the laser head cover.
2. Neatly fold a sheet of lens tissue into a rectangular shape (approximately 1/4 in. x 3/4 in.). Do not contaminate tissue with soiled or oily fingers.
3. Clamp and hold the tissue with hemostats. To avoid damage to an optic, ensure the hemostats are not close to the edge of the tissue.
4. Moisten the tissue with reagent grade methanol or acetone.
5. Gently wipe across the optic in one direction. One pass should be sufficient. Repeat if necessary with a clean tissue.

Cleaning Removed Optics

The following technique is recommended for optics that have been removed from the laser for a purpose other than cleaning. When possible, clean optics in place in the cavity.

1. Hold the optic element gently by the edge or place it on a clean work surface covered with lens tissue.
2. Place a few drops of acetone or methanol on one end of the lens tissue. Spectrophotometric or electronic grade is recommended. Handle the optic gently while cleaning it to avoid microfine abrasions.
3. Place the wet end of the lens tissue on the optic and pull it across the optic in one direction only. Do not rub the tissue back and forth. Note that the dry part of the tissue helps remove any acetone residue.
4. Repeat the above steps until the optic is clean, using a new lens tissue for each pass. Reusing tissue may lead to damage of the optic by dragging loose particles back across the surface.

Mira Wavelength Changes

There are three sets of optics for the Mira laser to cover the wavelength range from 720 nm to 990 nm. The optic sets are called short wavelength (SW), mid-wavelength (MW), and long wavelength (LW). Optic part numbers associated with these wavelengths are listed in Appendices A and B.

To change wavelengths from SW to LW or from LW to SW:

- Change all required optics (M1 through M10) using the steps in the optics replacement procedure for each optic.
- Perform the full alignment procedure in Chapter Five.
- Change the GTI using the procedure in this chapter.

To change wavelengths between adjacent optic sets (from SW to MW, MW to LW, LW to MW, or MW to SW):

- Starting with M1, replace optics M1 through M10, one optic at a time using the optics removal and installation procedure for each optic.
- Re-establish lasing after each optics replacement.
- Change the GTI using the procedure in this chapter.

Equipment Used During Optic Replacement

- Optics set for new operating wavelength.
- Accessory kit supplied with laser.
- Power meter, Coherent Model 210 or equivalent (0 to 10 W).
- Autocorrelator.
- Laser safety glasses to protect against the wavelength exiting the laser head and to protect against the pump beam wavelength. Refer to the fact sheets in Appendix A and to the pump laser operator's manual for specific wavelengths.

- IR viewer.
- Real time oscilloscope.

Optics Replacement

Use extreme care when removing optics from their mounts and do not touch the coated or polished surfaces.

The following procedure describes optic replacement for a damaged optic. To change the wavelength range, perform steps 1 through 3 of the optic replacement procedures for each optic (M1 through M10, then GTI) being replaced. Then perform the full alignment procedure in Chapter Five. Note the position and orientation of an optic prior to removal so the new optic can be re-installed in the same position and orientation. Replace only those optics required by the fact sheets to implement the wavelength change.

M1 Removal and Installation

To replace a damaged optic or convert to high power operation, perform all steps in the following procedure.

To change wavelengths from SW to LW or from LW to SW:

- Perform steps 1 through 4 of the following procedure to change M1.
- Change all required optics (M1 through M10) using steps 1 through 3 in the optics replacement procedure for each optic.
- Change the GTI using the procedure in this chapter.
- Perform the full alignment procedure in Chapter Five.

To change wavelengths between adjacent optic sets (from SW to MW, MW to LW, LW to MW, or MW to SW):

- Change M1 through M10, one optic at a time starting with M1. Perform steps 1 through 12 in the following procedure.
- Change the GTI using the procedure in this chapter.
- Re-establish lasing after each optics replacement.

1. Block the ion laser pump beam. Turn off the water to the crystal to prevent condensation.

2. Remove slit assembly by removing the 2 mounting screws (Figure 3-4).
3. Loosen the setscrew on top of the output coupler M1 mount (Figure 3-4) and remove the optic.
4. Clean both sides of the optic using the cleaning procedures. Using lens tissue to avoid touching the optical surfaces, install the new optic with the flat side facing up, and the arrow pointing towards M2. Tighten the setscrew.
5. Turn on the cooling water to the crystal and unblock the ion laser pump beam.
6. Set the CW/ML/β-Lock switch on the controller to CW. Hold the AUTO RANGE/PEAK RESET switch in the AUTO RANGE position for at least 2 seconds. This activates DC SUPPRESSION which is the most sensitive display on the controller.
7. Open the slit assembly by rotating the slit width control fully clockwise.
8. Close and adjust the M2 alignment aperture so that the fluorescent reflection from M3 is centered in the aperture.
9. Locate the retro-reflection from M1 on the M2 aperture using an IR viewer.
10. Adjust the M1 horizontal and vertical tilt angle controls to center the retro-reflection in the aperture.
11. Open the M2 aperture. Adjust M1 horizontal and vertical tilt angle controls to maximize the fluorescence on the controller display. If it does not lase after maximizing the fluorescence, refer to Figure 4-1.
12. Maximize output power using P2 and GTI horizontal and vertical tilt angle controls.
13. Re-install slit assembly. Open the slit assembly by rotating the slit width control fully clockwise.
14. Reduce the slit width (turn slit width control counterclockwise) until the output power is reduced approximately 50%.
15. Rotate the slit horizontal translation control for maximum output power. This centers the slit in the beam.
16. Repeat steps 12 and 13 to ensure slit is centered.
17. Set the CW/ML/β-Lock switch on the controller to the ML position. Optimize the BRF and slit width control for maximum power with zero CW content as viewed on the controller display.
    - The fast diode display from Mira laser head can be displayed on an oscilloscope to determine modelocked operation (Figure 4-3).
    - After system is modelocked, switch the controller to β-Lock position and adjust the bias level for optimum pulse width while observing the pulse on an oscilloscope via an autocorrelator.

M2 REMOVAL AND INSTALLATION

To replace a damaged optic, perform all steps in the following procedure.

To change wavelengths from SW to LW or from LW to SW:

- Perform steps 1 through 4 of the following procedure to change M2.
- Change all required optics (M1 through M10) using steps 1 through 3 in the optics replacement procedure for each optic.
- Change the GTI using the procedure in this chapter.
- Perform the full alignment procedure in Chapter Five.

To change wavelengths between adjacent optic sets (from SW to MW, MW to LW, LW to MW, or MW to SW):

- Change M1 through M10, one optic at a time starting with M1. Perform steps 1 through 8 in the following procedure.
- Change the GTI using the procedure in this chapter.
- Re-establish lasing after each optics replacement.

1. Block the ion laser pump beam. Turn off the water to the crystal to prevent condensation.
2. Remove the slit assembly by removing the two mounting screws (Figure 3-4).
3. Loosen the setscrew on the side of the M2 mount (Figure 3-8) and remove the optic. The optic can be removed by carefully pushing on the optic with a cotton swab through a hole on the rear of the optic mount.
4. Clean both sides of the optic using the cleaning procedures. Using lens tissue to avoid touching the optical surfaces, install the new optic and tighten the setscrew.
5. Turn on the cooling water to the crystal and unblock the ion laser pump beam.
6. Set the CW/ML/β-Lock switch on the controller to CW. Hold the AUTO RANGE/PEAK RESET switch in the AUTO RANGE position for at least 2 seconds. This activates DC SUPPRESS which is the most sensitive display on the controller.
7. Adjust the M2 horizontal and vertical tilt angle controls to center the fluorescence on the M1 optic. A white card or an IR viewer may assist in centering the fluorescence.

   If the Mira lases, proceed to step 8.

   If the Mira does not lase, adjust M2 horizontal and vertical tilt angle controls to maximize the fluorescence on the controller display. If the Mira does not lase after maximizing the fluorescence, refer to Figure 4-1.

8. Maximize output power using P2 and GTI horizontal and vertical tilt angle controls.
9. Block the ion laser pump beam. Turn off the water to the crystal to prevent condensation.
10. Re-install the slit assembly. Open the slit assembly by rotating the slit width control fully clockwise.
11. Turn on the cooling water to the crystal and unblock the ion laser pump beam.
12. Reduce the slit width (turn slit width control counterclockwise) until the output power is reduced approximately 50%.
13. Rotate the slit horizontal translation control for maximum output power. This centers the slit in the beam.
14. Repeat steps 12 and 13 to ensure slit is centered.
15. Set the CW/ML/β-Lock switch on the controller to the ML position. Optimize the BRF and slit width control for maximum power with zero CW content as viewed on the controller display.
    - The fast diode display from Mira laser head can be displayed on an oscilloscope to determine modelocked operation (Figure 4-3).
    - After system is modelocked, switch the controller to β-Lock position and adjust the bias level for optimum pulse width while observing the pulse on an oscilloscope via an autocorrelator.

M3 Removal and Installation

To replace a damaged optic, perform all steps in the following procedure.

To change wavelengths from SW to LW or from LW to SW:

- Perform steps 1 through 5 of the following procedure to change M3.
- Change all required optics (M1 through M10) using steps 1 through 3 in the optics replacement procedure for each optic.
- Change the GTI using the procedure in this chapter.
- Perform the full alignment procedure in Chapter Five.

To change wavelengths between adjacent optic sets (from SW to MW, MW to LW, LW to MW, or MW to SW):

- Change M1 through M10, one optic at a time starting with M1. Perform steps 1 through 9 in the following procedure.
- Change the GTI using the procedure in this chapter.
- Re-establish lasing after each optics replacement.

1. Block the ion laser pump beam. Turn off the water to the crystal to prevent condensation.
2. Remove the slit assembly by removing the two mounting screws (Figure 3-4).
3. The M3 optic is very close to the butterfly. Avoid touching the butterfly during M3 removal. If the butterfly is accidentally touched, clean the butterfly after M3 installation is complete using the cleaning procedures in this chapter.
4. Loosen the setscrew on the side of the M3 mount (Figure 3-4) and remove the optic. The optic can be removed by carefully pushing on the optic with a cotton swab through a hole on the rear of the optic mount.
5. Clean both sides of the optic using the cleaning procedures. Using lens tissue to avoid touching the optical surfaces, install the new optic and tighten the setscrew.
6. Turn on the cooling water to the crystal and unblock the ion laser pump beam.
7. Set the CW/ML/β-Lock switch on the controller to CW. Hold the AUTO RANGE/PEAK RESET switch in the AUTO RANGE position for at least 2 seconds. This activates DC SUPPRESS which is the most sensitive display on the controller.
8. Adjust M3 horizontal and vertical tilt angle controls to center the fluorescence on the M1 optic. A white card or an IR viewer may assist in centering the fluorescence.

   If the Mira lases, proceed to step 9.

   If the Mira does not lase, adjust M3 horizontal and vertical tilt angle controls to maximize the fluorescence on the controller display. If the Mira does not lase after maximizing the fluorescence, refer to Figure 4-1.
9. Maximize output power using P2 and GTI horizontal and vertical tilt angle controls.
10. Block the ion laser pump beam. Turn off the water to the crystal to prevent condensation.
11. Re-install the slit assembly. Open the slit assembly by rotating the slit width control fully clockwise.
12. Turn on the cooling water to the crystal and unblock the ion laser pump beam.
13. Reduce the slit width (turn slit width control counterclockwise) until the output power is reduced approximately 50%.
14. Rotate the slit horizontal translation control for maximum output power. This centers the slit in the beam.
15. Repeat steps 13 and 14 to ensure slit is centered.

16. Set the CW/ML/β-Lock switch on the controller to the ML position. Optimize the BRF and slit width control for maximum power with zero CW content as viewed on the controller display.
    - The fast diode display from Mira laser head can be displayed on an oscilloscope to determine modelocked operation (Figure 4-3).
    - After system is modelocked, switch the controller to β-Lock position and adjust the bias level for optimum pulse width while observing the pulse on an oscilloscope via an autocorrelator.

M4 Removal and Installation

To replace a damaged optic, perform all steps in the following procedure.

To change wavelengths from SW to LW or from LW to SW:

- Perform steps 1 through 4 of the following procedure to change M4.
- Change all required optics (M1 through M10) using steps 1 through 3 in the optics replacement procedure for each optic.
- Change the GTI using the procedure in this chapter.
- Perform the full alignment procedure in Chapter Five.

To change wavelengths between adjacent optic sets (from SW to MW, MW to LW, LW to MW, or MW to SW):

- Change M1 through M10, one optic at a time starting with M1. Perform steps 1 through 9 in the following procedure.
- Change the GTI using the procedure in this chapter.
- Re-establish lasing after each optics replacement.

1. Block the ion laser pump beam. Turn off the water to the crystal to prevent condensation.
2. Loosen two thumbnuts and remove the beam shield (Figure 3-17).
3. Remove the two knurled thumbscrews on the rear of the M4 mount (Figure 3-21) and remove the mirror holder and optic. Do not allow the thumbscrews to touch focusing lens L1.
4. Clean both sides of the optic using the cleaning procedures. Using lens tissue to avoid touching the optical surfaces, install the new optic into the holder. Place the optic holder in the mount and evenly tighten the two knurled thumbscrews.
5. Re-install the beam shield.
6. Turn on the cooling water to the crystal and unblock the ion laser pump beam.

7. Set the CW/ML/β-Lock switch on the controller to CW. Hold the AUTO RANGE/PEAK RESET switch in the AUTO RANGE position for at least 2 seconds. This activates DC SUPPRESS which is the most sensitive display on the controller.
8. Adjust M4 horizontal and vertical tilt angle controls to maximize reading on controller display.

   If the Mira lases, proceed to step 10.

   If the Mira does not lase, make small adjustments to M5 horizontal and vertical tilt angle controls to maximize the fluorescence on the controller display. If the Mira does not lase after maximizing the fluorescence, refer to Figure 4-1.
9. Maximize output power using P2 and GTI horizontal and vertical tilt angle controls.
10. Re-install slit assembly. Open the slit assembly width control fully clockwise.
11. Reduce the slit width (turn slit width control counterclockwise) until the output power is reduced approximately 50%.
12. Rotate the slit horizontal translation control for maximum output power. This centers the slit in the beam.
13. Repeat steps 11 and 12 to ensure slit is centered.

Set the CW/ML/β-Lock switch on the controller to the ML position. Optimize the BRF and slit width control for maximum power with zero CW content as viewed on the controller display.

- The fast diode display from Mira laser head can be displayed on an oscilloscope to determine modelocked operation (Figure 4-3).
- After system is modelocked, switch the controller to β-Lock position and adjust the bias level for optimum pulse width while observing the pulse on an oscilloscope via an autocorrelator.

M5 Removal and Installation

To replace a damaged optic, perform all steps in the following procedure.

To change wavelengths from SW to LW or from LW to SW:

- Perform steps 1 through 3 of the following procedure to change M5.
- Change all required optics (M1 through M10) using steps 1 through 3 in the optics replacement procedure for each optic.
- Change the GTI using the procedure in this chapter.
- Perform the full alignment procedure in Chapter Five.

To change wavelengths between adjacent optic sets (from SW to MW, MW to LW, LW to MW, or MW to SW):

- Change M1 through M10, one optic at a time starting with M1. Perform steps 1 through 7 in the following procedure.
- Change the GTI using the procedure in this chapter.
- Re-establish lasing after each optics replacement.

1. Block the ion laser pump beam. Turn off the water to the crystal to prevent condensation.
2. Loosen the two M5 assembly thumbscrews on the rear of the M5 mount (Figure 3-5) and remove the beam block. Remove the smaller knurled screws from the rear of the mount and remove the optic holder.
3. Clean both sides of the optic using the cleaning procedures. Using lens tissue to avoid touching the optical surfaces, install the new optic into the holder. Place the optic holder in the mount and evenly tighten the two knurled thumbscrews (Figure 3-5).
4. Turn on the cooling water to the crystal and unblock the ion laser pump beam.
5. Set the CW/ML/β-Lock switch on the controller to CW. Hold the AUTO RANGE/PEAK RESET switch in the AUTO RANGE position for at least 2 seconds. This activates DC SUPPRESS which is the most sensitive display on the controller.
6. Adjust (very small adjustments) M5 horizontal and vertical tilt angle controls to maximize the fluorescence on the controller display.

   If the Mira lases, proceed to step 8.

   If the Mira does not lase after maximizing the fluorescence, refer to Figure 4-1.
7. Maximize output power using P2 and GTI horizontal and vertical tilt angle controls.
8. Reduce the slit width (turn slit width control counterclockwise) until the output power is reduced approximately 50%.
9. Rotate the slit horizontal translation control for maximum output power. This centers the slit in the beam.
10. Repeat steps 9 and 10 to ensure slit is centered.
11. Set the CW/ML/β-Lock switch on the controller to the ML position. Optimize the BRF and slit width control for maximum power with zero CW content as viewed on the controller display.
    - The fast diode display from Mira laser head can be displayed on an oscilloscope to determine modelocked operation (Figure 4-3).

- After system is modelocked, switch the controller to β-Lock position and adjust the bias level for optimum pulse width while observing the pulse on an oscilloscope via an autocorrelator.

M8 Removal and Installation

To replace a damaged optic, perform all steps in the following procedure.

To change wavelengths from SW to LW or from LW to SW:

- Perform steps 1 through 3 of the following procedure to change M8.
- Change all required optics (M1 through M10) using steps 1 through 3 in the optics replacement procedure for each optic.
- Change the GTI using the procedure in this chapter.
- Perform the full alignment procedure in Chapter Five.

To change wavelengths between adjacent optic sets (from SW to MW, MW to LW, LW to MW, or MW to SW):

- Change M1 through M10, one optic at a time starting with M1. Perform steps 1 through 7 in the following procedure.
- Change the GTI using the procedure in this chapter.
- Re-establish lasing after each optics replacement.

1. Block the ion laser pump beam. Turn off the water to the crystal to prevent condensation.
2. Loosen the setscrew on the side of the M8 mount (Figure 3-2) and remove the optic. The optic can be removed by carefully pushing on the optic with a cotton swab through a hole on the rear of the optic mount.
3. Clean both sides of the optic using the cleaning procedures. Using lens tissue to avoid touching the optical surfaces, install the new optic and tighten the setscrew.
4. Turn on the cooling water to the crystal and unblock the ion laser pump beam.
5. Set the CW/ML/β-Lock switch on the controller to CW. Hold the AUTO RANGE/PEAK RESET switch in the AUTO RANGE position for at least 2 seconds. This activates DC SUPPRESS which is the most sensitive display on the controller.
6. Adjust M8 horizontal and vertical tilt angle controls to center the reflection on M10.

   If the Mira lases, proceed to step 8.

   If the Mira does not lase, make minor adjustments to the M8 horizontal and vertical tilt angle controls to maximize the fluorescence on the

controller display. If it does not lase after maximizing the fluorescence, refer to Figure 4-1.

7. Maximize output power using P2 and GTI vertical and horizontal tilt angle controls.
8. Re-install slit assembly. Open the slit assembly width control fully clockwise.
9. Reduce the slit width (turn slit width control counterclockwise) until the output power is reduced approximately 50%.
10. Rotate the slit horizontal translation control for maximum output power. This centers the slit in the beam.
11. Repeat steps 10 and 11 to ensure slit is centered.
12. Set the CW/ML/β-Lock switch on the controller to the ML position. Optimize the BRF and slit width control for maximum power with zero CW content as viewed on the controller display.
    - The fast diode display from Mira laser head can be displayed on an oscilloscope to determine modelocked operation (Figure 4-3).
    - After system is modelocked, switch the controller to β-Lock position and adjust the bias level for optimum pulse width while observing the pulse on an oscilloscope via an autocorrelator.

M10 Removal and Installation

To replace a damaged optic, perform all steps in the following procedure.

To change wavelengths from SW to LW or from LW to SW:

- Perform steps 1 through 3 of the following procedure to change M10.
- Change all required optics (M1 through M10) using steps 1 through 3 in the optics replacement procedure for each optic.
- Change the GTI using the procedure in this chapter.
- Perform the full alignment procedure in Chapter Five.

To change wavelengths between adjacent optic sets (from SW to MW, MW to LW, LW to MW, or MW to SW):

- Change M1 through M10, one optic at a time starting with M1. Perform steps 1 through 7 in the following procedure.
- Change the GTI using the procedure in this chapter.
- Re-establish lasing after each optics replacement.

1. Block the ion laser pump beam. Turn off the water to the crystal to prevent condensation.

2. Loosen the optic setscrew on the top of the M10 mount (Figure 3-6) and remove the optic. The optic can be removed by carefully pushing on the optic with a cotton swab through a hole on the rear of the optic mount.
3. Clean both sides of the optic using the cleaning procedures. Using lens tissue to avoid touching the optical surfaces, install the new optic and tighten the setscrew.
4. Turn on the cooling water to the crystal and unblock the ion laser pump beam.
5. Set the CW/ML/β-Lock switch on the controller to CW. Hold the AUTO RANGE/PEAK RESET switch in the AUTO RANGE position for at least 2 seconds. This activates DC SUPPRESS which is the most sensitive display on the controller.
6. Adjust the M10 horizontal and vertical tilt angle controls to place the retro-reflection next to the pump beam on the M8 optic. See Figure 5-4.

If the Mira lases, proceed to step 8.

If the Mira does not lase, make small adjustments to M10 horizontal and vertical tilt angle controls to maximize the fluorescence on the controller display. If it does not lase after maximizing the fluorescence, refer to Figure 4-1.

7. Adjust GTI horizontal and vertical for maximum output.
8. Re-install slit assembly. Open the slit width control fully clockwise.
9. Reduce the slit width (turn slit width control counterclockwise) until the output power is reduced approximately 50%.
10. Rotate the slit horizontal translation control for maximum output power. This centers the slit in the beam.
11. Repeat steps 10 and 11 to ensure slit is centered.
12. Set the CW/ML/β-Lock switch on the controller to the ML position. Optimize the BRF and slit width control for maximum power with zero CW content as viewed on the controller display.
    - The fast diode display from Mira laser head can be displayed on an oscilloscope to determine modelocked operation (Figure 4-3).
    - After system is modelocked, switch the controller to β-Lock position and adjust the bias level for optimum pulse width while observing the pulse on an oscilloscope via an autocorrelator.

GTI Assembly Removal and Installation

To replace a damaged GTI assembly, perform all steps in the following procedure.

To change wavelengths from SW to LW or LW to SW:

- Perform steps 1 through 7 of the following procedure to change the GTI assembly.
- Change all required optics (M1 through M10) using steps 1 through 3 in the optics replacement procedure for each optic.
- Perform the full alignment procedure in Chapter Five.

To change the wavelengths between adjacent optics sets (from SW to MW, MW to LW, LW to MW, or MW to SW):

- Change M1 through M10, one optic at a time, starting with M1. Perform steps 1 through 11 in the following procedure
- Change the GTI assembly
- Re-establish lasing after each optic replacement.

1. Block the ion laser pump beam. Turn off the water to the crystal to prevent condensation.
2. Turn off the power switch on the Mira controller.
3. Disconnect the two SMC connectors from the rear of the GTI assembly (Figure 3-18).
4. Loosen the setscrew on the GTI mount (Figure 3-18) and remove the assembly towards the rear of the mount.
5. Clean the exposed optic surface of the GTI assembly. Install the new GTI assembly and tighten the setscrew.
6. Reconnect GTI electrical connectors.
7. Power on Mira controller.
8. Turn on the cooling water to the crystal and unblock the ion laser pump beam.
9. Set the CW/ML/β-Lock switch on the controller to CW. Hold the AUTO RANGE/PEAK RESET switch in the AUTO RANGE position for at least 2 seconds. This activates DC SUPPRESS which is the most sensitive display on the controller.
10. Open the slit assembly by rotating the slit width control clockwise.
11. Adjust GTI mount for maximum fluorescence and establish lasing.
12. Reduce the slit width (turn slit width control counterclockwise) until the output power is reduced approximately 50%.
13. Rotate the slit horizontal translation control for maximum output power. This centers the slit in the beam.
14. Repeat 12 and 13.
15. Set the CW/ML/β-Lock switch on the controller to the ML position. Optimize the BRF and slit width control for maximum power with zero CW content as viewed on the controller display.

- The fast diode display from Mira laser head can be displayed on an oscilloscope to determine modelocked operation (Figure 4-3).
- After system is modelocked, switch the controller to β-Lock position and adjust the bias level for optimum pulse width while observing the pulse on an oscilloscope via an autocorrelator.\

L1 Removal and Installation

Perform the following procedure to replace a damaged optic.

1. Remove M10 mount.
2. If lens L1 is not badly damaged, note where the pump beam strikes M9. If this cannot be done due to severe damage to L1, proceed to step 5.
3. If the beam is not in the center of M9, adjust M8 horizontal and vertical tilt angle controls to center the pump beam on M9.
4. If possible, re-establish lasing using M9 horizontal and vertical tilt angle controls.
   - Set the CW/ML/β-Lock switch on the controller to CW. Hold the AUTO RANGE/PEAK RESET switch in the AUTO RANGE position for at least 2 seconds. This activates DC SUPPRESS which is the most sensitive display on the controller.
   - It may be necessary to adjust the M9 horizontal and vertical tilt angle controls to place the retro-reflection next to the pump beam on the M8 optic.

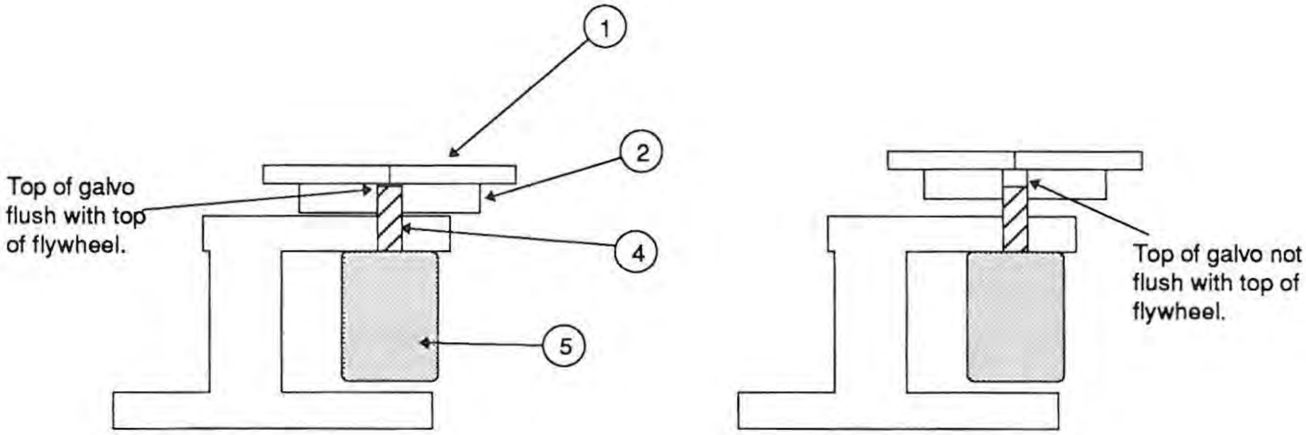
   If it is not possible to re-establish lasing, proceed to step 5.
5. Block the ion laser pump beam. Turn off the water to the crystal to prevent condensation.
6. Adjust the ion laser so that the output power is approximately 100 mW.
7. Using an Allen wrench, loosen the setscrew on the top of the L1 mount (Figure 3-14) and remove the optic.
8. Clean both sides of the new optic using the cleaning procedures. The lens has a curved side and a flat side. Using lens tissue to avoid touching the optical surfaces, install the new optic with the flat side facing M4. Tighten the setscrew so the lens can be moved but will not slip.
9. Turn on the crystal assembly cooling water and unblock the ion laser pump beam.
10. Loosen the two 3/32 inch screws that hold the lens holder onto the translation stage so that the holder doesn't slip. Adjust the position of the lens so that the pump beam is centered on M9. Tighten the screws.
11. Verify that the pump beam is still centered on M9. If not, repeat step 10.

12. Retract the beam shields (Figure 3-3) and verify that the beam is passing through the center of the crystal. The beam should also pass through the center (within 1 mm) of M4.
13. Set the CW/ML/b-Lock switch on the controller to CW. Hold the AUTO RANGE/PEAK RESET switch in the AUTO RANGE position for at least 2 seconds. This activates DC SUPPRESS which is the most sensitive display on the controller.
14. Open the slit assembly by rotating the slit width control clockwise.
15. Adjust the ion laser to normal operating power.
16. If the Mira lases, proceed to step 17.

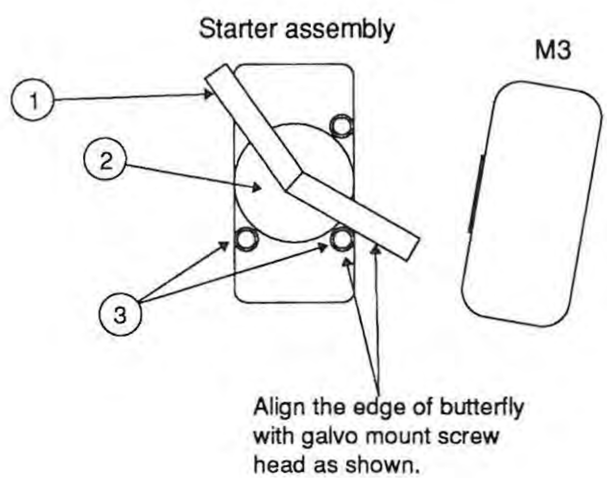
    If the Mira does not lase use, adjust the P2 pump controls and maximize the fluorescence on the controller display. If it does not lase after maximizing the fluorescence, refer to Figure 4-1.
17. Reduce the slit width (turn slit width control counterclockwise) until the output power is reduced approximately 50%.
18. Rotate the slit horizontal translation control for maximum output power. This centers the slit in the beam.
19. Repeat steps 17 and 18 to ensure slit is centered.
20. Set the CW/ML/b-Lock switch on the controller to the ML position. Optimize the BRF and slit width control for maximum power with zero CW content as viewed on the controller display.
    - The fast diode display from Mira laser head can be displayed on an oscilloscope to determine modelocked operation (Figure 4-3).

STARTER BUTTERFLY REMOVAL AND INSTALLATION

1. Block the ion laser pump beam. Turn off the water to the crystal to prevent condensation.
2. Loosen the two setscrews (Figure 3-15) securing the butterfly assembly on the galvo shaft.
3. Install the new butterfly assembly so that top of the shaft is level with the top surface of the stainless steel flywheel (Figure 6-1A). Do not tighten the mounting setscrews at this point.
4. Position the butterfly (without moving the shaft) as shown on Figure 6-1B for a rough Brewster angle adjustment. The starter assembly can be damaged if it is over extended. Tighten the mounting setscrews.
5. Turn on the water to the crystal, and unblock the ion laser pump beam.
6. Set the BRF micrometer to obtain maximum power.
7. Open the slit assembly by rotating the slit width control clockwise.



A — SIDE VIEW



B — TOP VIEW

1. Starter assembly butterfly
2. Stainless steel flywheel
3. Allen head screws (4)
4. Galvo shaft
5. Galvo

Figure 6-1. Starter Butterfly Installation

8. Set the CW/ML/b-Lock switch on the controller to ML.
9. Connect an oscilloscope to the POWER OUT connector on the rear of the controller. A periodic signal will appear.
10. Loosen the starter assembly Allen head screw (Figure 3-15). Move the starter assembly back and forth while noting the different waveforms that appear on the scope. Adjust the starter assembly so that the dip in the waveform increases until the waveform is at twice the frequency as when it is misaligned. The is also the position of minimum peak to peak signal.
11. Tighten the starter assembly Allen head screw.
12. Clean the butterfly while holding the stainless steel flywheel to prevent the shaft from turning.

OPERATOR'S MANUAL

CHAPTER EIGHT
CONVERSIONS

COHERENT®

CONVERSION PROCEDURE FROM FEMTOSECOND TO PICOSECOND

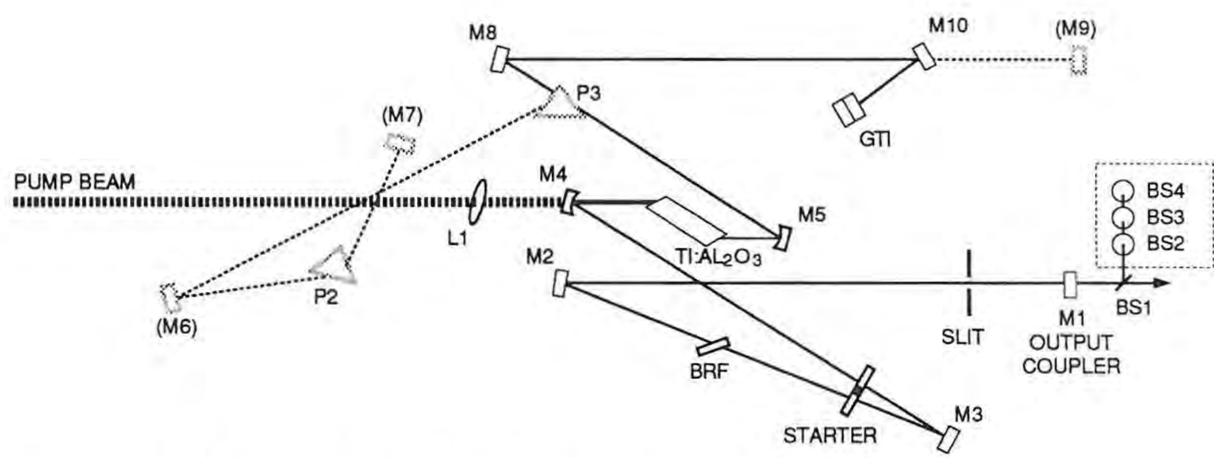
CONVERSION SUMMARY

A summary of Mira conversion from femtosecond to picosecond is listed below. The following paragraphs in this section contain detailed procedures for each item listed below.

- Remove BP1 from beam path.
- Remove and install picosecond output coupler.
- Remove and install picosecond birefringent filter.
- Install the M10 optical mount assembly.

BP1 REMOVAL

1. Turn the BP1 micrometer clockwise (towards the lower reading) until it stops. This will translate the prism out of the beam path. Refer to the optical schematic Figure 8-1.
2. Verify that the birefringent filter is at the peak of the tuning curve. Refer to the tuning chart for the micrometer setting.
3. Open the slit assembly by rotating the slit width control clockwise.
4. Make small adjustments to the following controls to maximize the power on the control display. Adjust one control at a time and in the order listed.
   - P2 vertical and horizontal tilt angle controls.
   - M9 vertical and horizontal tilt angle controls.



Note: Solid lines represent picosecond operation.
Solid lines and dashes represent femtosecond operation.

Figure 8-1. Dual Cavity Configured for Femtosecond Operation

M1 Removal and Installation

1. Block the ion laser pump beam. Turn off the water to the crystal to prevent condensation.
2. Loosen the setscrew on top of the output coupler M1 mount Figure 3-4 and remove the optic.
3. Clean both sides of the optic using the cleaning procedures. Using lens tissue to avoid touching the optical surfaces, install the new optic with the flat side facing up, and the arrow pointing towards M2. Tighten the setscrew.
4. Turn on the cooling water to the crystal and unblock the ion laser pump beam.
5. Set the CW/ML/β-Lock switch on the controller to CW. Hold the AUTO RANGE/PEAK RESET switch in the AUTO RANGE position for at least 2 seconds. This activates DC SUPPRESS which is the most sensitive display on the controller.
6. Open the slit assembly by rotating the slit width control clockwise.
7. Close and adjust the M2 alignment aperture so that the fluorescent reflection from M3 is centered in the aperture.
8. Locate the retro-reflection from M1 on the M2 aperture using an IR viewer.
9. Adjust the M1 horizontal and vertical tilt angle controls to center the retro-reflection in the aperture.
10. Open the M2 aperture. Adjust M1 horizontal and vertical tilt angle controls to maximize the fluorescence on the controller display. If it does not lase after maximizing the fluorescence, refer to Figure 4-1.
11. Maximize output power using P2 and M9 horizontal and vertical tilt angle controls.

Birefringent Filter Removal and Replacement

1. Block the ion laser pump beam. Turn off the water to the crystal to prevent condensation.
2. Remove the button head screw on the side of the Birefringent filter assembly (Figure 3-7). Remove the one plate birefringent filter and replace it with the three plate birefringent filter.
3. Close and center the apertures on M2 and M3.
4. Use M3 vertical and horizontal tilt angle controls to center the fluorescence on the M2 aperture. It may be necessary to reposition the birefringent filter in the holder to avoid clipping of the beam. To reposition the filter, loosen the BRF setscrew on the side of the outer ring of the birefringent filter assembly and slide the inner ring until the beam no longer is clipping. Refer to Figure 3-7.

5. Use the M2 vertical and horizontal tilt angle controls to position the fluorescence on to the center of the output coupler M1.
6. Locate the retro-reflection from M1 on the M2 aperture. An IR viewer will make the spot easier to locate. Adjust M1 vertical and horizontal tilt angle controls until the retro-reflection is centered in the aperture. Open the M2 aperture.
7. Make small adjustments to the following controls to maximize the intensity on the controller display. Adjust one control at a time and the order listed below.
   - M9 vertical and horizontal tilt angle controls.
   - Output coupler M1 vertical and horizontal tilt angle controls.

   Repeat this step until the Mira is lasing, maximize power using the M9 controls and M1 controls after lasing starts.
8. Once cavity is lasing, maximize output power by adjusting the following:
   - Output coupler M1 vertical and horizontal tilt angle controls.
   - M5 vertical and horizontal tilt angle controls (small adjustments).
   - P2 vertical and horizontal tilt angle controls.
9. Adjust the birefringent filters Brewster's angle by loosening the BRF Brewster's angle adjust screws (Figure 3-7). Rotate the BRF assembly counter clockwise until maximum power has been achieved. Once the Brewster's angle has been set, tighten the two adjust screws.
10. Verify that the birefringent filter is set to the proper tuning order. Refer to the tuning chart for the micrometer setting or Figure 8-2 for correct filter orientation.

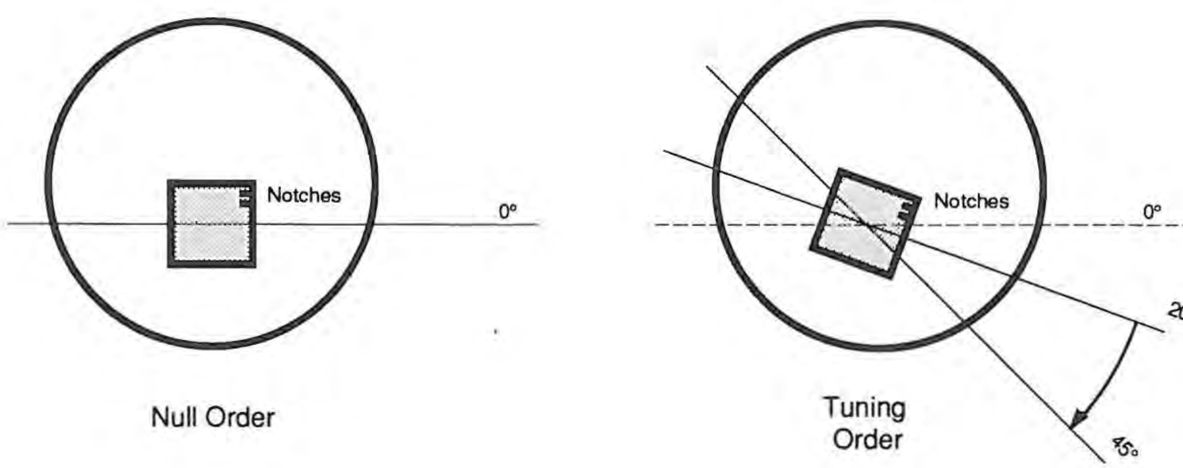


Figure 8-2. Birefringent Filter Tuning Order

11. Using an IR viewer to verify that the beam travels through the exact center of both butterfly arms vertically. If not, use the M3 vertical tilt angle control to adjust the vertical position on the butterfly arm closest to the slit. Use M4 vertical tilt angle control to adjust the vertical position on the butterfly arm closest to the side. Refer to the paragraph titled "Walking The Beam".

M10 Optical Mount Installation

1. Block the ion laser pump beam. Turn off the water to the crystal to prevent condensation.
2. Instal the M10 optical mount assembly as shown in Figure 3-1.
3. Locate the pump beam retro-reflection (in front of M8) from M5. Use the vertical and horizontal tilt angle controls to center the pump beam in the center of the M10 optic.
4. Adjust the ion laser to the proper operating level and turn on the cooling water to the crystal.
5. Locate the pump beam retro-reflection (in front of GTI) from M10. Position the pump beam approximately one beam diameter from center at 2 o'clock position on the GTI optic.
6. Set the CW/ML/β-Lock switch on the controller to CW. Hold the AUTO RANGE/PEAK RESET switch in the AUTO RANGE position for at least 2 seconds. This activates DC SUPPRESS which is the most sensitive display on the controller.
7. Adjust the GTI vertical and horizontal tilt angle controls to maximize the intensity on the controller.
8. Once cavity is lasing, maximize the output power by adjusting the following controls:
   - GTI vertical and horizontal tilt angle controls.
   - M1 output coupler vertical and horizontal tilt angle controls.
   - P2 vertical and horizontal tilt angle controls.

Modelocking

1. After output power is maximized using the GTI, reduce the slit width (turn slit width control counterclockwise) until the output power is reduced approximately 50%.
2. Rotate the slit horizontal translation control for maximum output power. This centers the slit in the beam.
3. Repeat steps 1 and 2 to ensure slit is centered.

4. Set the CW/ML/β-Lock switch on the controller to the ML position. Optimize the BRF and slit width control for maximum power with zero CW content as viewed on the controller display.
   - The fast diode display from Mira laser head can be displayed on an oscilloscope to determine modelocked operation (Figure 4-3).
   - After system is modelocked, switch the controller to β-Lock position and adjust the bias level for optimum pulse width while observing the pulse on an oscilloscope via an autocorrelator.

WALKING THE BEAM

Walking the beam refers to the procedure to adjust the beam position between two adjacent mirrors such as M2 and M3. This is done while the system is lasing.

Assume that the beam is not striking M2 in the center. Walk the beam as follows:

1. Adjust the M3 vertical tilt angle control to move the beam in the direction to center the beam on M2 until the power has decreased approximately 20%.
2. Adjust M2 vertical and horizontal tilt angle controls to recover power.
3. Repeat steps 1 and 2 until the position on M2 is satisfactory. Each repetition of steps 1 and 2 moves the beam about 0.25 to 0.5 mm.
4. Performing steps 1 through 3 affects the beam position on all optics on the same side of the crystal. Continue to walk the beam on all optics progressing to the end mirror as listed below.
   - M4, M3, M2, M1
   - M5, M8, M10
   - M10, GTI

CONVERSION PROCEDURE FROM PICOSECOND TO FEMTOSECOND

CONVERSION SUMMARY

A summary of Mira conversion from picosecond to femtosecond is listed below. The following paragraphs in this section contain detailed procedures for each item listed below.

- Remove and install birefringent filter.
- Remove and installation of the output coupler.
- Remove M10 optical assembly.

- Installation of BP1 into the beam path.

Birefringent Filter Removal and Replacement

1. Block the ion laser pump beam. Turn off the water to the crystal to prevent condensation.
2. Remove the button head screw on the side of the Birefringent filter assembly, Refer to Figure 3-7. Remove the three plate birefringent filter and replace it with the one plate birefringent filter.
3. Close and center the apertures on M2 and M3.
4. Turn on the cooling water to the crystal and unblock the ion laser pump beam.
5. Use M3 vertical and horizontal tilt angle controls to center the fluorescence on the M2 aperture. It may be necessary to reposition the birefringent filter in the holder to avoid clipping of the beam. To reposition the filter, loosen the BRF setscrew on the side of the outer ring and slide the inner ring until the beam no longer is clipping. Refer to Figure 3-7.
5. Use the M2 vertical and horizontal tilt angle controls to position the fluorescence on to the center of the output coupler M1.
6. Locate the retro-reflection from M1 on the M2 aperture. An IR viewer will make the spot easier to locate. Adjust M1 vertical and horizontal tilt angle controls until the retro-reflection is centered in the aperture. Open the M2 aperture.
7. Set the CW/ML/β-Lock switch to CW position and toggle the AUTO RANGE/PEAK RESET switch to PEAK RESET.
8. Hold the AUTO RANGE/PEAK RESET switch in the AUTO RANGE position for at least 2 seconds to activate the DC suppress function.
9. Open the slit by rotating the slit width control (Figure 3-4) clockwise until it stops.
10. Make small adjustments to the following controls to maximize the intensity on the controller display. Adjust one control at a time and the order listed below.
    - GTI vertical and horizontal tilt angle controls.
    - Output coupler M1 vertical and horizontal tilt angle controls.

    Repeat this step until the Mira is lasing, maximize power using the GTI controls and M1 controls after lasing starts.
11. Once cavity is lasing, maximize output power by adjusting the following:
    - Output coupler M1 vertical and horizontal tilt angle controls.
    - M5 vertical and horizontal tilt angle controls (small adjustments).

- P2 vertical and horizontal tilt angle controls.

12. Adjust the birefringent filters Brewster's angle by loosening the BRF Brewster's angle adjust screws. Figure 3-7. Rotate the BRF assembly counter clockwise until maximum power has been achieved. Once the Brewster's angle has been set, tighten the two adjust screws.
13. Verify that the birefringent filter is at the peak of the tuning curve. Refer to tuning chart for micrometer setting.
14. Using an IR viewer to verify that the beam travels through the exact center of both butterfly arms vertically. If not, use the M3 vertical tilt angle control to adjust the vertical position on the butterfly arm closest to the slit. Use M4 vertical tilt angle control to adjust the vertical position on the butterfly arm closest to the side. Refer to the paragraph titled "Walking The Beam".

M1 Removal and Installation

1. Block the ion laser pump beam. Turn off the water to the crystal to prevent condensation.
2. Loosen the setscrew on top of the output coupler M1 mount (Figure 3-4) and remove the optic.
3. Clean both sides of the optic using the cleaning procedures located in Chapter Six, Maintenance. Using lens tissue to avoid touching the optical surfaces, install the new optic with the flat side facing up , and the arrow pointing towards M2. Tighten the setscrew.
4. Turn on the cooling water to the crystal and unblock the ion laser pump beam.
5. Set the CW/ML/β-Lock switch on the controller to CW. Hold the AUTO RANGE/PEAK RESET switch in the AUTO RANGE position for at least 2 seconds. This activates DC SUPPRESS which is the most sensitive display on the controller.
6. Open the slit by rotating the slit width control (Figure 3-4) clockwise until it stops.
7. Close and adjust the M2 alignment aperture so that the fluorescent reflection from M3 is centered in the aperture.
8. Locate the retro-reflection from M1 on the M2 aperture using an IR viewer.
9. Adjust the M1 horizontal and vertical tilt angle controls to center the retro-reflection in the aperture.
10. Open the M2 aperture. Adjust M1 horizontal and vertical tilt angle controls to maximize the fluorescence on the controller display. If it does not lase after maximizing the fluorescence, refer to Figure 4-1.

11. Maximize output power using P2 and GTI horizontal and vertical tilt angle controls.

M10 Optical Mount Removal and M9 Alignment

1. Block the ion laser pump beam. Turn off the water to the crystal to prevent condensation.
2. Remove the M10 optical assembly by loosening the two screws at the base. See Figure 3-6.
2. Locate the pump beam (in front of M8) from M5. Use M8 vertical and horizontal tilt angle controls to center the pump beam on the M9 optic.
3. Locate the pump beam retro-reflection from M9 as follows:
   - Adjust the ion laser to high power.
   - Adjust the vertical and horizontal tilt angle controls to locate the retro-reflection from M9.
   - The correct retro-reflection is the brightest of the two reflections.
   - Adjust the vertical and horizontal tilt angle controls to position the retro-reflection one beam diameter to the right of the pump beam on M8.
4. Set the CW/ML/β-Lock switch on the controller to CW. Hold the AUTO RANGE/PEAK RESET switch in the AUTO RANGE position for at least 2 seconds. This activates DC SUPPRESS which is the most sensitive display on the controller.
5. Make small adjustments to the following controls to maximize the intensity on the controller display. Adjust one control at a time and in this order.
   - M9 vertical and horizontal tilt angle controls.
   - Output coupler M1 vertical and horizontal tilt angle controls.
6. Once cavity is lasing, maximize the output power by adjusting the following controls:
   - Output coupler M1 vertical and horizontal tilt angle controls.
   - M9 vertical and horizontal tilt angle controls.
   - P2 vertical and horizontal tilt angle controls.

BP1 Installation

1. Turn BP1 micrometer counterclockwise (towards higher micrometer reading) to translate prism BP1 into the beam path so that the output power is reduced by 50%. Refer to Figure 3-2.
2. Place white card directly in front of M7. The laser alignment beam should be visible on the card. If using SW or MW, tune wavelength to

approximately 800 nm. If using LW optics, tune to approximately 1000 nm. Adjust M6 horizontal and vertical tilt angle controls to center the spot on M7. Close and adjust the M6 aperture to center the aperture on the diffracted laser beam spot.

3. Adjust the M6 aperture so that the spot is visible on M7. An IR viewer will make the spot easier to locate. Locate the retro-reflected spot (from M7) on the M6 aperture face. Adjust M7 horizontal and vertical tilt angle controls to position the retro-reflection into the M6 alignment aperture.
4. Translate BP1 (turn micrometer counterclockwise) into the beam path so that the prism is not clipping the beam. This can be determined by placing a white card in front of M9. Translate BP1 until the pump beam is no longer visible on the card. Once the pump beam disappears, turn the micrometer an additional 4 turns counterclockwise.
5. Remove white card from laser cavity. Toggle the controller AUTO RANGE/PEAK RESET switch to PEAK RESET. Open the aperture on M6.
6. Set the CW/ML/β-Lock switch on the controller to CW. Hold the AUTO RANGE/PEAK RESET switch in the AUTO RANGE position for at least 2 seconds. This activates DC SUPPRESS which is the most sensitive display on the controller.
6. Use only the M7 vertical and horizontal tilt angle controls and the CW display to optimize power output.

MODELOCKING

1. After output power is maximized using M7, reduce the slit width (turn slit width control counterclockwise) until the output power is reduced approximately 50%.
2. Rotate the slit horizontal translation control for maximum output power. This centers the slit in the beam.
3. Repeat steps 1 and 2 to ensure slit is centered.
4. Set the CW/ML/β-Lock switch on the controller to ML. Optimize the slit width control for maximum power with zero CW content as viewed on the controller display.
   - The fast diode display from Mira laser head can be displayed on an oscilloscope to determine modelocked operation (Figure 4-3).

WALKING THE BEAM

Walking the beam refers to the procedure to adjust the beam position between two adjacent mirrors such as M2 and M3. This is done while the system is lasing.

Assume that the beam is not striking M2 in the center. Walk the beam as follows:

1. Adjust the M3 vertical tilt angle control to move the beam in the direction to center the beam on M2 until the power has decreased approximately 20%.
2. Adjust M2 vertical and horizontal tilt angle controls to recover power.
3. Repeat steps 1 and 2 until the position on M2 is satisfactory. Each repetition of steps 1 and 2 moves the beam about 0.25 to 0.5 mm.
4. Performing steps 1 through 3 affects the beam position on all optics on the same side of the crystal. Continue to walk the beam on all optics progressing to the end mirror as listed below.
   - M4, M3, M2, M1
   - M5, M6, M7
   - M5, M8, M9

Operator's Manual

Appendix A
Tuning Curves

COHERENT®

Operator's Manual

Appendix B
Parts List

COHERENT®

The following parts can be ordered by contacting Coherent Customer Service at 1-800-367-7890.

Crystal: 0165-582-00 $5482

DESCRIPTION	PART NUMBER
Starter assembly (not including galvo)	0163-147-00
Starter galvo	4900-0014
Birefringent filter (not including retainer ring)	0163-800-00
Accessory kit	0162-019-00
Alignment aperture assembly	0163-114-00
L1 alignment aperture assembly	0162-963-00
CW etalon detector assembly (not including galvo)	0163-148-00
Galvo assembly	4900-0014
Controller	0163-709-01
Cable (between controller and laser head)	
Pump optics P0 through P4, flat	0161-712-00
Focusing lens L1	0163-052-00

SW OPTIC SET	0163-149-00
Output coupler M1, flat, low power	0163-652-00
Output coupler M1, flat, high power	0163-653-00
Mirror M2, flat	0159-791-09
Mirror M3, flat	0158-791-09
Mirror M4, 10 cm	0163-048-00
Mirror M5, 10 cm	0163-050-00
Auxiliary cavity mirror M8, flat	0158-791-09
Auxiliary cavity mirror M10, flat	0158-791-09
Gires-Tournois Interferometer (GTI)	0163-799-00

MW OPTIC SET	0163-149-01
Output coupler M1, flat, low power	0163-654-00
Output coupler M1, flat, high power	0163-655-00
Mirror M2, flat	0159-791-11
Mirror M3, flat	0158-791-11
Mirror M4, 10 cm	0163-048-01
Mirror M5, 10 cm	0163-050-01
Auxiliary cavity mirror M8, flat	0158-791-11
Auxiliary cavity mirror M9, flat	0158-791-11
Gires-Tournois Interferometer (GTI)	0163-799-01

LW OPTIC SET	0163-149-02
Output coupler M1, flat, low power	0163-656-00
Output coupler M1, flat, high power	0163-657-00
Mirror M2, flat	0159-791-13
Mirror M3, flat	0158-791-13
Mirror M4, 10 cm	0163-048-02
Mirror M5, 10 cm	0163-050-02
Auxiliary cavity mirror M8, flat	0158-791-13
Auxiliary cavity mirror M10, flat	0158-791-13
Gires-Tournois Interferometer (GTI)	0163-799-02

Operator's Manual

Appendix C
Warranty

COHERENT.

Responsibilities of the Buyer

The Buyer must provide the appropriate utilities and operating environment outlined in the product literature and/or the Preinstallation Manual. Damage to the laser system caused by failure of Buyer's utilities or the Buyer's failure to maintain an appropriate operating environment, is solely the responsibility of the Buyer and is specifically excluded from any warranty, warranty extension, or service agreement.

The Buyer is responsible for prompt notification to Coherent of any claims made under warranty. In no event will Coherent be responsible for warranty claims later than seven (7) days after the expiration of the warranty.

Limitations of Warranty

The foregoing warranty shall not apply to defects resulting from:

1 Components or accessories with separate warranties manufactured by companies other than Coherent.

2 Improper or inadequate maintenance by Buyer.

3 Buyer-supplied interfacing.

4 Operation outside the environmental specifications of the product.

5 Improper site preparation and maintenance.

6 Unauthorized modification or misuse.

Coherent assumes no responsibility for customer-supplied material.

The obligations of Coherent are limited to repairing or replacing, without charge, equipment which proves to be defective during the warranty period. Repaired or replaced parts are warranted for the duration of the original warranty period only. This warranty does not cover damage due to misuse, negligence or accidents, or damage due to installations, repairs or adjustments not specifically authorized by Coherent.

This warranty applies only to the original buyer at the initial installation point in the country of purchase, unless otherwise specified in the sales contract. Warranty is transferable to another location or to another Buyer only by special agreement which will include additional inspection or installation at the new site.

THE WARRANTY SET FORTH ABOVE IS EXCLUSIVE IN LIEU OF ALL OTHER WARRANTY, WHETHER WRITTEN, ORAL OR IMPLIED, AND DOES NOT COVER INCIDENTAL OR CONSEQUENTIAL LOSS. COHERENT SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

Coherent Mira Model 900-P Laser Operator's Manual

Coherent Part Number: 0163-882-99, Preliminary

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2. Improper or inadequate maintenance by Buyer.
3. Buyer-supplied interfacing.
4. Operation outside the environmental specifications of the product.
5. Improper site preparation and maintenance.
6. Unauthorized modification or misuse.

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Warranty

Coherent, Inc. warrants to the original purchaser (the Buyer) only, that the laser system, that is the subject of this sale, (a) conforms to Coherent's published specifications and (b) is free from defects in materials and workmanship.

Laser systems are warranted to conform to Coherent's published specifications and to be free from defects in materials and workmanship for a period of twelve (12) months. This warranty covers travel expenses for the first ninety (90) days. For systems that include installation in the purchase price, this warranty begins at installation or thirty (30) days from shipment, whichever occurs first. For systems which do not include installation, this warranty begins at date of shipment.

Optical Products

Coherent optical products are unconditionally warranted to be free of defects in materials and workmanship. Discrepancies must be reported to Coherent within thirty (30) days of receipt, and returned to Coherent within ninety (90) days. Adjustment is limited to replacement, refund or repair at Coherent's option.

Conditions of Warranty

On-site warranty services are provided only at the installation point. If products eligible for on-site warranty and installation services are moved from the original installation point, the warranty will remain in effect only if the Buyer purchases additional inspection or installation services at the new site.

For warranty service requiring the return of any product to Coherent, the product must be returned to a service facility designated by Coherent. The Buyer is responsible for all shipping charges, taxes and duties covered under warranty service.

Parts replaced under warranty shall become the property of Coherent and must be returned to Coherent, Inc., Palo Alto, or to a facility designated by Coherent. The Buyer will be obligated to issue a purchase order for the value of the replaced parts and Coherent will issue credit when the parts are received.

Other Products

Other products not specifically listed above are warranted to, (a) conform to Coherent's published specifications and (b) be free from defects in materials and workmanship. This warranty covers parts and labor and is for a period of twelve (12) months from the date of shipment.

Operator's Manual

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Warranty

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